THE ENGINEER

MAY 28, 1954

Forty-Second Wilbur Wright Lecture

THE choice of power units for civil aeroplanes was the subject of the forty-second Wilbur Wright Memorial Lecture given by Dr. A. E. Russell before the Royal Aeronautical Society on May 20th. Dr. Russell opened his address on a cautious note. He said it was necessary to "restrain the eye from wandering too far ahead, waiting for the exciting prospects that periodically stream into aeronautical vision"; among the developments influencing the thrust and drag characteristics of aircraft he would ignore in his present survey would be the application of nuclear energy and the extensive use of boundary layer suction leading to supersonic flight. He referred to the argument, propaganda and confusion which existed in this whole field. Dr. Russell then proceeded to compare the major characteristics of the turbo-jet the turbo-propeller and the ducted fan engine, and included an analysis of propeller performance. He maintained that because of the relatively greater fall of propulsive efficiency with higher jet velocities, specific fuel consumption actually increased with increase of cycle temperature in the pure jet engine and, therefore, their potential improvement in subsonic aircraft would be of a small order. With respect to the turbo-propeller engine, he showed that due to compressibility effects a Mach number of 0·75 would be the probable limit of forward speed. He then went on to discuss the influence of the principal parameters in the design and performance of a civil aircraft. In his conclusions Dr. Russell maintained that the pure jet engine was the least well suited to the requirements of civil aviation. By comparison with other types its adoption led to the largest, heaviest and least economic aircraft. If the highest speeds were essential then ducted fan engines were better. When the excitement of a new form of propulsion had abated, the realisation of the greater potential capacity of the turbo-prop engine for civil aviation would be universally accepted. In the future, aeroplanes fitted with this type of engine would form the substantial proportion of the fleets of all airlines. For any given duty they would be smaller, lighter, more economic and versatile than any other kind. Even on long journeys the time differential with possible competing forms would be so small that the chance of solvency offered better attractions.

Locomotive Manufacturers' Association of Great Britain

LAST week the Locomotive Manufacturers' Association of Great Britain held a dinner and dance in honour of the visitors to the International Railway Congress in London. About 300 members of the Association and their guests attended the dinner, which was presided over by Mr. John F. Alcock, who proposed the only toast of the evening—"The International Railway Congress." Mr. Alcock pointed out that since 1925, when the Congress was last held in this country, there had been many developments, both technical and political. He said that when railways began to improve communications between countries some hundred years ago, there was every promise that they would improve international understanding and relationships, but as subsequent events showed these hopes had not been realised. In more recent years, with the introduction of other forms of transport, it had been said that railways were out of date—but they still played a leading role in transport of people and materials and would continue to do so for many years to come. Mr. Alcock reminded his listeners of the fact that in this country the railways built practically all of the locomotives required for their own use, and the private builders therefore depended upon overseas exports for their products. The healthy state of this great branch of industry was indicative of the excellence of British locomotives and the esteem in which they were held in all parts of the world. A response to the toast was made by Sir Gilmour Jenkins, the senior member of the Permanent Committee of the International Railway Congress.

World Production by A.D. 2000

THE first Fawley Foundation Lecture at Southampton University was given last week by Sir Harold Hartley who took for his subject "Science and Industry: The Pattern of the Future." In this address Sir Harold said he sought to give a brief sketch of the changes he had noted in the pattern of science and industry over the past fifty years, and then to make his own guesses at the ways in which they might work together to meet the material needs of the world in the second half of this century. After dealing with the future of agriculture, which was the world's biggest industry, he said that it was difficult to estimate the world's requirements of industrial goods by the year 2000. By that time he thought that output would have to rise 350 per cent, involving an estimated increase in energy consumption of 125 per cent and of raw materials of 300 per cent, allowing for economies in manufacture. Sir Harold said that the availability of water would determine the future location of cities and industry and the size of industrial concentrations. Surveys and planning were needed to ensure that the utmost use was made of our water resources. By the year 2000 he considered there would be no global shortage of energy, although its availability might determine where development took place. In 1950 the world's consumption was equivalent to 3600 million tons of coal; in the year 2000, if industrial production had risen by 3 per cent a year, the demand for energy should be equivalent to 7500 million tons.

Kelvin Medal Award to Dr. C. J. Mackenzie

ON Wednesday, June 2nd, the Kelvin Medal for 1953 will be formally presented to Dr. C. J. Mackenzie at the Institution of Mechanical Engineers by Field Marshal Earl Alexander of Tunis. The Kelvin Medal is awarded triennially as a mark of distinction to engineers and scientists whose work is of a kind with which the late Lord Kelvin was identified. The medal fund is administered by the Institution of Civil Engineers, and the award is made by a committee of the presidents, for the time being, of the participating institutions after they have considered recommendations from similar bodies in all parts of the world. Dr. Mackenzie, who is the president of the Atomic Energy Control Board of Canada, will give an address entitled "The National Significance of Two Decades of Engineering Research in Canada," after he has received the medal. Dr. Mackenzie was born in New Brunswick in 1888 and graduated at Dalhouse University in 1909 and at Harvard University in 1915. He joined the staff of the engineering firm of Maxwell and Mackenzie in 1912 and served with it until 1916, when he joined the Armed Forces. He was Professor of Civil Engineering at the University of Saskatchewan from 1918 till 1939, and was Dean of the College of Engineering from 1921 till 1939. From that year until 1952 Dr. Mackenzie was president of the National Research Council of Canada, and in 1952 he was appointed president of Atomic Energy of Canada, Ltd. He became a member of the Atomic Energy Control Board in 1946 and has been president of the Board since 1948.

Scottish Industries Exhibition

SOME details about the Scottish Industries Exhibition were announced at a press conference in London last Monday evening. The exhibition is to be held in the Kelvin Hall, Glasgow, from September 2nd to 18th, and is being promoted by the Scottish Council (Development and Industry). The last such exhibition was held in 1949. The catalogue of the exhibition shows that manufacturing industry in Scotland will be fully represented, more than 300 firms having taken space. At the press conference, Mr. R. A. Maclean, chairman of the exhibition council of management, said that 100 different industries would be represented, some industries having as many as half a dozen different manufacturers. The stand frontage at the exhibition would be approximately 1½ miles in length, and everything shown would be made in Scotland. The Secretary of State for Scotland, Mr. James Stuart, said at the conference that visitors to the exhibition would find that the development of new scientific industries in Scotland had proceeded at a considerable pace since the last exhibition was held. By the time the next exhibition came along there would be, he was confident, more striking evidence of the growing volume of research work now being done at East Kilbride, in the universities and in many other places. During the press conference it was stated that the last exhibition was attended by over 500,000 people, including 30,000 trade buyers from all parts of the world, and that the orders received were valued at more than £10,000,000. Mr. M. H. Donaldson is the general manager of the exhibition, the offices of which are at 1, Castle Street, Edinburgh, 2.

Annual Road Research Report

THE importance of the research work carried out by the Road Research Laboratory is emphasised in its annual report, published this week. It is noted with concern, in the Board's introductory report, that road accidents are steadily increasing as the number of vehicles is growing. It is feared that this trend will continue unless active and sometimes drastic steps are taken to ensure that existing knowledge is rapidly applied and the fullest use made of scientific investigation. The Board is disturbed to find that the number of accidents in which skidding is reported remains high despite the general improvement in the surfaces of main roads. Higher speeds of modern traffic demand road surfaces of even greater resistance to skidding particularly on curves. The report reveals that despite the public notice taken of the Road Research Laboratory's findings, many vehicles still have bad brakes and poor headlights. The Board stresses its belief that some more positive action is needed before any radical and far-reaching improvements will occur. Particular attention is being paid to motor-assisted cycles whose use is growing rapidly. Investigation shows that many of these machines have inadequate lights and brakes and that bicycle type brakes that will remain effective in wet weather are required. Accident hazards may also arise because the drivers of other vehicles mistake these machines for ordinary cycles and underestimate their speed. The report of the Director of Road Research, which accompanies the report of the Board, summarises the progress of the Laboratory's work during the year. The latter part of the report is concerned with road construction and deals with such aspects as road structure, soil stabilisation, kinds and treatment of aggregate, weathering, adhesion and oxidisation properties of tars, the use of pulverised fuel ash and snow fences.

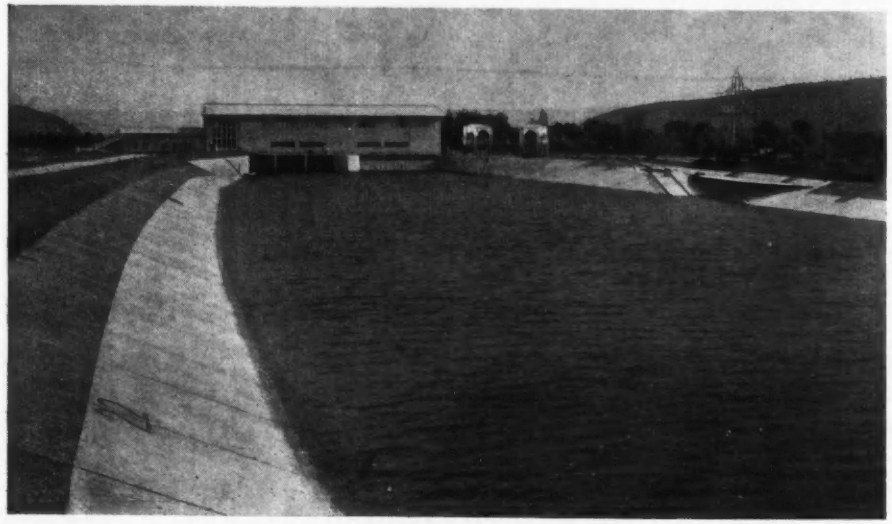


Fig. 25—Power station and head race canal

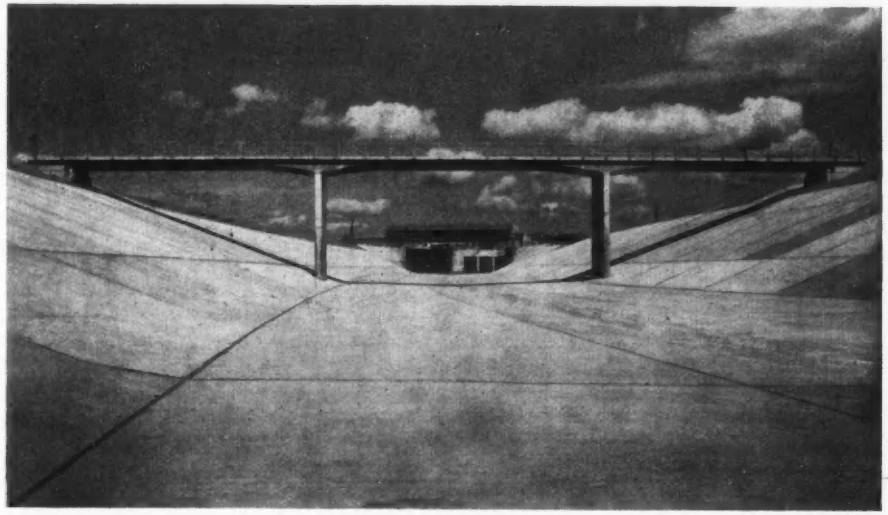


Fig. 26—Prestressed concrete footbridge over head race canal

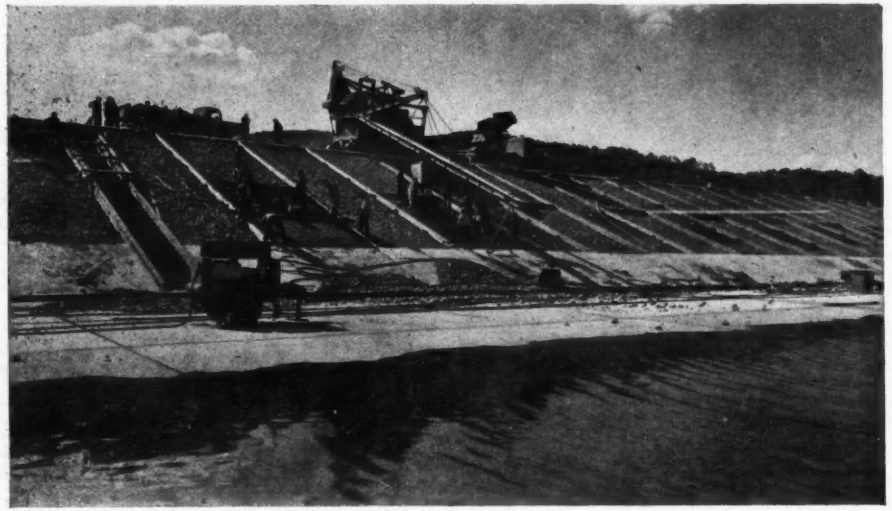


Fig. 27—Concreting canal bank

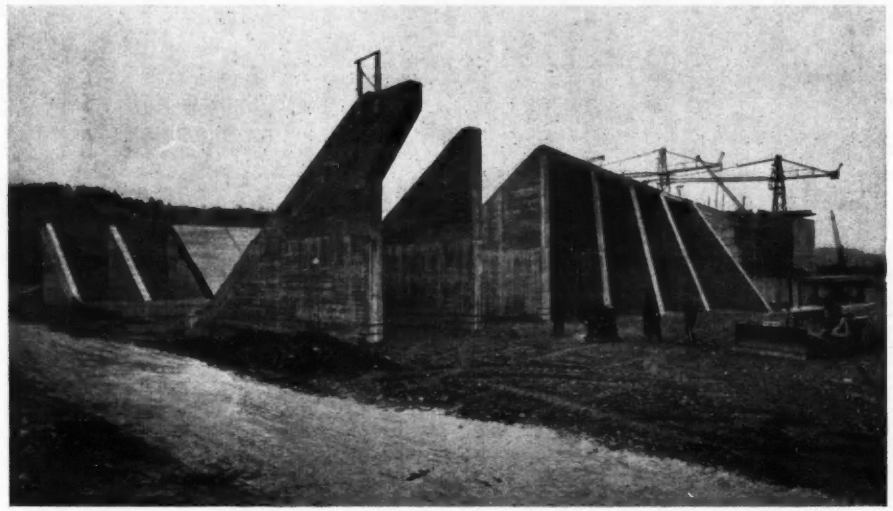


Fig. 28—Construction of head race canal next to power station

Some Recent Swiss Hydro-Electric Schemes

No. VI—(*Continued from page 736, May 21st*)

Two run-of-river schemes in Northern Switzerland are described in this series. The development recently completed on the River Aare between the towns of Wildegg and Brugg forms the subject of the present article. This scheme will generate about 300 million kWh each year, and has an installed capacity of 46MW ; the gross head of the scheme is 15·7m.

As a contrast from the various mountain schemes described in the earlier parts of this series, an account is given here of two recent low-head projects in Northern Switzerland. The Wildegg-Brugg scheme utilises a length of nearly 10km of the River Aare between the two towns from which it takes its name, immediately below the tail-race canal of the Rupperswil-Auenstein scheme. It will produce about 300 million kWh annually with an installed capacity of 46MW utilised at a fairly high load factor. The Birsfelden project on the River Rhine close to Basle will generate about 362 million kWh annually and will have an installed capacity of about 90MW in four similar sets. In both of these schemes the production of energy is fairly evenly spaced throughout the year, but is slightly greater in summer. For instance, the Wildegg-Brugg scheme will generate 57 per cent of its annual output, namely, 170 million kWh, during the summer months, whilst at Birsfelden 55 per cent of the power will be generated in the summer.

The Wildegg-Brugg scheme consists of a diversion canal along the left bank of the Aare, 4·5km in length, with the power station situated about halfway along it. A barrage has been built across the river at the canal intake, thus raising the river level ; the effect of the barrage extends upstream for about 5km, over which distance the river is largely confined between earthen embankments ; however, the forebay thus formed cannot be drawn down and the scheme is essentially a run-of-river installation. There is a subsidiary barrage across the Aare nearly 2km below the principal barrage, but its purpose is purely one of amenity. There are thermal springs on the right bank of the river, just below the main dam, the waters of which have been widely used for many years. The concession for the hydro-electric scheme stipulated that the springs should not be interfered with in any way ; it was therefore found necessary to maintain the water table in the neighbourhood of the springs at the level obtaining before the construction of the scheme. The head-race canal has a water-tight lining of concrete and thus has no appreciable effect on the water table. It was, however, essential to maintain the level of the river Aare at its natural height for that length of the river running beside the springs. With the diversion of most of the flow into the power canal, it was therefore necessary to build the subsidiary barrage to maintain the required river level over that critical length.

Both the main and subsidiary barrages are shown in cross section in Fig. 29. The subsidiary dam has automatic bear-trap gates, the operation of which may be observed from the illustration. There is a float in one of the piers of the dam (not shown in Fig. 29) which actuates a cylindrical valve. When the float rises above a given level, the valve opens, thus releasing water from the space enclosed by the two elements of the gate ; the gate then starts to collapse, as indicated by the dotted outlines of the illustration. The barrage consists of four 22·5m bays and was constructed inside the cover of steel sheet-piled cofferdams. The service bridge over the top of it consists of a number of box-section prestressed concrete beams. The beams are simply supported and were post-tensioned by the B.B.R.V. system, a method used extensively in Switzerland. They were cast on the bank and rolled into position along a service bridge built on the downstream side.

For maintenance of the gates a steel lattice beam is placed across one bay of the barrage at about the top water level where shoulders have been built on to the piers for this purpose. Needles are then emplaced, vertically, side by side, each one supported by a groove in the sill of the barrage at the bottom and by the steel beam at the top. This arrangement is shown dotted in the illustration : the lattice beam is also shown dotted suspended from a rail on the underside of the bridge cantilever, thus illustrating the method of moving it to the bay where it is required. The construction of the gates of the subsidiary barrage is illustrated in Figs. 30 and 31.

The form of the principal barrage is also clearly shown in Fig. 29. It consists of four bays each of 15m and closed by a sector gate, fitted with a "shutter" at the top, which may be lowered to give adjustment of the forebay level over a range of 1·5m. The sharp drop in level of the bottom of the barrage just downsteam from the gate sill may be noted, as well as the toothed form of the lower sill. This configuration was evolved from hydraulic model tests, to give the optimum scour protection from the heavy spillway discharges that are likely to occur in early summer. The rock on which the dam is built—marl (kalkmergel)—although structurally strong enough is rather vulnerable to scour. The arrangement has the additional advantage that all the gate mechanism is in the dry, above the tail water level. Sector gates of the kind shown in Fig. 29 have been employed on several Continental hydro-electric schemes, notably at La Vanelle on the Isere and the Donzere barrage on the Rhone, both in France, which have been described in this journal. One of the advantages claimed for them is that they require less power for their operation than other designs, so that smaller winches may be used, small enough for installation in winch houses on the piers of the barrage.

The power canal starts on the left bank side of the reservoir next to the main barrage. Its intake consists of a rather high concrete sill, so that solid material rolled down by the river is excluded from the canal, and may be passed through the sluiceways of the barrage when the gates are raised. A flow of 10 cumecs of compensation water is provided down the river. This compensation flow passes through a small Kaplan turbo-alternator set which has been installed in a subsidiary power station at the barrage, working under the head of 7·4m (maximum), created by the barrage. This set has an installed capacity of 650kW and generates at 50 c/s, 0·4kV, 300 r.p.m. Its power is transformed to 8·2kV and then used for the main power station auxiliaries, and for operating the winches of the barrage.

The main power station of the scheme is shown in Fig. 25. Its architecture is typical of several contemporary Swiss hydro-electric power stations. The two turbo-alternator

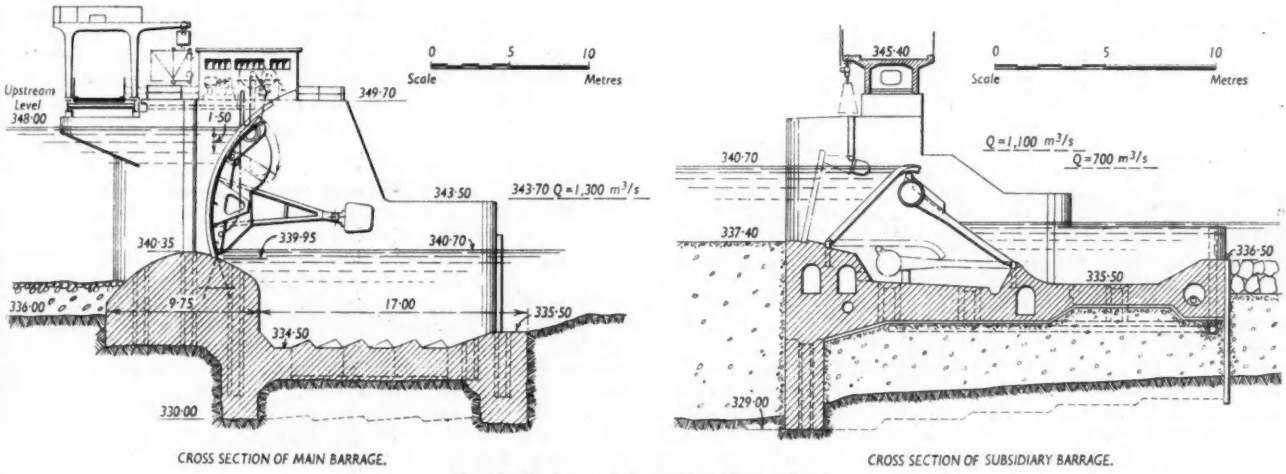


Fig. 29—Barrages of the Wildegg-Brugg scheme

sets are driven by vertical-shaft Kaplan turbines, operating under a net head of 14·75m (gross head 15·7m) each with a rated flow of 175 cumecs. The installed capacity of each machine set, corresponding to these conditions of head and flow, is 23MW and they generate at 8·2kV, 50 c/s, at 115·4 r.p.m. There are two 20MVA, 8·2/50kV transformers for local power supply, and two 30MVA, 8·2/150kV transformers for connection to the grid.

A point of interest is that the power station has a symmetrical layout and the two machine sets are of opposite hand and rotate in opposite directions. The length of the power station was slightly reduced by this arrangement, thus economising on the quantity of excavation and concrete in the constructional work, which was carried out under rather difficult conditions. It was necessary to enclose the power station site with a steel-sheet-piled cofferdam and install well points before the excavation could be attempted. The power station building has a welded steel structural frame.

Our illustration Fig. 25 shows the power station from the upstream ; the two mechanical rakes used for cleaning the screens may be observed on the right : for emplacing stop-logs these two machines are coupled together, as they are shown in the illustration, and they then have sufficient power to lift and transport the stop-logs. Scour in the power station tail race is minimised by rip-rap consisting of precast concrete cubes, each 1 cubic metre in size.

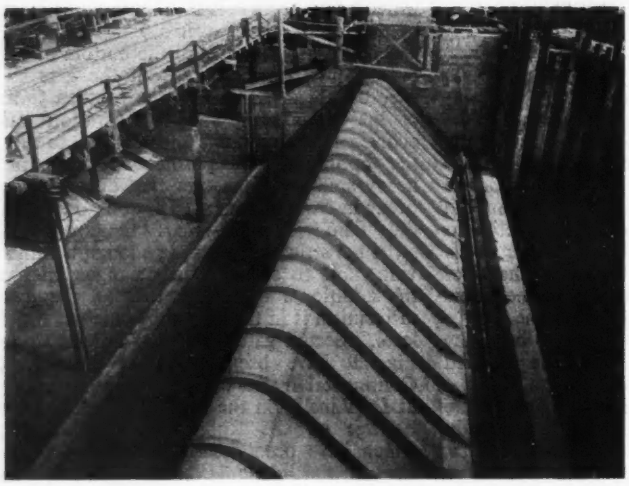
Excavation of the canal and the construction of the various dykes and berms of the canal and forebay formed one of the major tasks of the scheme and presented several problems. The various embankments were built of well-compacted layers of filling material, gravel being utilised wherever possible. In constructing a berm the top soil was first removed and a layer of gravel 30cm thick was then spread over the required area and compacted, and subsequent layers built up from it. For the embankments built along the river banks to form the forebay, sheet piling was driven at the embankment toes to reduce seepage. Near the canal and barrage the banks were concreted as well, and a concrete capping beam was formed along the top of the sheet piles. The head-race canal was lined with concrete throughout. All the concrete was placed *in situ*, generally with a thickness of 20cm, vibrated, and jointed with bituminous joints. The well-known double-drum mobile concrete mixing machine which was developed for airfield runway construction was used to emplace the concrete in the bottom of the canal. It was also employed in a slightly modified form for the slopes. With one modification a belt conveyor was used to carry the concrete down the slope ; in a second modification the arm carrying the concrete skip was replaced by a long beam, extending to the bottom of the slope and propped at the bottom end as in Fig. 27. A rate of concreting of 80 cubic metres per hour was achieved with this arrangement.

Construction of the concrete lining of the head-race canal next to the power station is shown in progress in Fig. 28. It will be seen that the inclined slabs of reinforced concrete forming the lining are carried on cross-walls and the fill forming the embankment was placed in position after the concrete work was complete ; the compacting machine may be noted.

The tail-race canal is not lined with concrete. It was, however, necessary to build flood banks along the Aare to prevent inundation of the canal when floods are experienced, and to carry out some river training works where it joins the river. For the river embankments of the forebay drainage ditches have been built on the landward side to carry off seepage, and a pumping station has been built to drain a low-lying area of ground on the right bank of the Aare. The normal depth of water in both the head-race and tail-race canals is about 7m to 9m. The side slopes are generally about 1 : 2·5, and the bottom widths vary from 20m to 40m, the water flowing at about 1m or 1·2m per second to give the rated flow of 350 cumecs. The total quantity of excavation involved in the construction of the canals and power station was about 3·3 million cubic metres and about 1·4 million cubic metres was necessary to construct the embankments. An area of 230,000 square metres of concrete lining was also emplaced.

It will be seen that the problems encountered with the Wildegg-Brugg scheme were very different from those of the high-head schemes we have described earlier. The fact that the scheme has been built in a well populated and highly developed area has exercised no small influence in its design, and considerable attention has been paid to amenity. The construction of the subsidiary barrage has already been mentioned, but that was not the only work carried out to ensure that the project did not have any adverse effect on its surroundings. All the spoil tips have been graded to blend with the existing ground contours—particularly at the power station site where considerable " landscaping " has been carried out—and covered with soil for agricultural use. Fish passes have been built at the power station and the two barrages and a boat slipway for hauling small boats past the power station have been constructed. (the upstream end of this slipway may be seen on the right of Fig. 25). Several new bridges have been built across the forebay and canals. There is a continuous three-span welded steel road bridge across the river, with a central span of 48·60m, which has a slender and attractive appearance. Fig. 26 shows a prestressed concrete road bridge over the head-race canal. This bridge was also post-tensioned according to the B.B.R.V. system. It is continuous over the three spans and in cross-section comprises a single slab for the full width of the bridge, as the illustration shows. The centre span is 24m and the two side spans are each 19·5m. The cost of constructing the Wildegg-Brugg scheme was about 94,5000,000 Swiss francs (nearly £8,000,000) based on 1947 prices.

(To be continued)



Figs. 30 and 31—Bear trap gates of subsidiary barrage

Runway Expansion Joint Filler

THE gaps caused by the extrusion of non-resilient fillers and their failure to follow the movement of concrete has meant serious maintenance problems at airports and has endangered aircraft. This failure to recover creates a gap through which water and grit may leak down to the subsoil, and can result in a buckling and cracking of the concrete or cause subsidence. To jet machines landing at high speeds the distortion occasioned by ineffective fillers can be disastrous.

A filler which, the makers state, overcomes these defects is now being produced at a North London factory by Celotex, Ltd., from sugar cane fibres which are highly resilient. The Air Ministry specification for expansion joint fillers requires a return to 70 per cent of their original thickness after they have been compressed to 50 per cent. Recent tests carried out by an Air Ministry approved laboratory on these sugar cane fibre fillers, called " Flexcell," showed a recovery of 93 per cent.

This filler is now a priority requirement in the construction of modern airports and airfields, in every part of the world, designed to take jet aircraft. The sugar cane fibres are imported by the company from the British West Indies and are the residue after the juice has been pressed from the cane.

French Locomotive Experiences

By EDWARD H. LIVESAY

(*Continued from page* 739, *May 21st*)

No. X—PARIS/STRASBOURG/PARIS : FOUR-CYLINDER COMPOUND 4-6-0, 4-6-2 AND 4-8-2 LOCOMOTIVES, AND PNEUMATIC-TYRED TRAIN

THE French locomotive experiences described in this series were all so interesting that it is difficult to decide which were outstanding, but none was more so than those dealt with in this article, owing to the unique character of the Michelin-tyred coaches and the engine that hauled them from Paris to Strasbourg, and the fine work done on the return trip by " Pacific " and " Mountain " machines. All three engines were in fine condition, and their performances flawless ; the speeds were high, the terrain was beautiful, and Strasbourg, the " turn-around " point, where a night was spent, was delightful, giving me an opportunity to make brief acquaintance with this charming old city under the guidance of an official of the S.N.C.F., Monsieur Calmus, native of it and the neighbouring country, whose company had much to do with the pleasure of the excursion.

The Gare de l'Est, where the runs began and ended, is, as the name suggests, in East-Central Paris, and to reach it from my *pied à terre* at Asnières, via the Gare St. Lazare, both north-west, took an hour or so, by electric train and bus or Metro (Underground) from the latter terminus. A bus appealed to me most, as from it one sees varied Parisian life—especially if one stands on the back platform. At the Gare de l'Est I was greeted by sundry officials, among them Monsieur Calmus,* who was coming with me in the cab as interpreter and courier. The train was made up of, I think, ten steel coaches, each running on twenty Michelin pneumatic-tyred wheels, in two groups of ten at each end, and weighed about 400 tons ; it was headed by an old streamlined, " high-wheeled," 4-6-0, four-cylinder compound engine, No. 230-K242 (Fig. 51), which happened to be the first of the class, its chief particulars being as follows :—

Cylinders :	
H.P.	14·6in × 26·8in
L.P.	23·2in × 26·8in
Piston valves	Walschaerts valve gear (l.p. valves double ported)
Driving wheels, diameter	6ft 10·5in
Steam pressure	257 lb
Firebox, Belpaire narrow, grate area	33·5 sq ft
Heating surface, evaporation	1569 sq ft
Superheating surface	495 sq ft
Boiler, length between tube plates	14ft 5in
Lemaître blast pipe	Trefoil
Weight on driving axles	56·9 tons
Weight, total	82·2 tons
Maximum drawbar horsepower	1350 at 55 m.p.h.

A.C.F.I. feed water heater.
Single burner firing.

This class was first built about forty years ago, but all have subsequently been rebuilt on Chapelon principles, embodying improved steam flow, both to and from the cylinders, higher superheat, and so forth, with the result that the highest possible pressure is obtained in the steam chests with the lowest possible exhaust pressure. They are capable of hauling 380 tons up 1 in 125 at 50 m.p.h. and maintaining 70 m.p.h. on the level with 600 tons on cut-offs 40 per cent h.p. and 50 per cent l.p. The following account of the work done between Paris and Strasbourg by the first of the class will show that after forty years they are still in splendid condition —if this one was representative—and running as well as ever.

The line to Strasbourg, which lies 312 miles to the east, is approximately level for the first 127 miles to Vitry le François, except for 7 miles near Meaux, the junction for Reims, so a very condensed profile (Fig. 52) suffices for this stretch. After Vitry it becomes more demanding, a heavy rise beginning at Bar le Duc, culminating in several miles at 1 in 125 to the summit at Loxéville, 166 miles, after which, through Toul to Nancy, the gradient mostly falls, followed by easy fluctuations, nothing very serious, over the rest of the way to Strasbourg.

On getting aboard, I guessed the cab was going to be warmer than usual, as it was more closed in and draught-proof than non-streamlined engines, but it was cleaner and brighter than the generality of French cabs, one of the advantages of oil fuel ; I am convinced no engineer would use coal if oil were possible. There were the usual twin regulators, the subsidiary one admitting live steam to the l.p. cylinders when necessary. Seats were provided for the enginemen, not always the case on older French locomotives, and the working timetable hung in its neat frame in front of the *mécanicien*, a sensible piece of furniture that I suggest B.R. adopt forthwith —to see it is to like it. A complete array of fittings and indicative gauges was in evidence, as is always the case on French engines, old or new. On them one notices that whatever is useful, or can add to efficiency or ease of handling, is provided, including electric light, audible signalling and speed indicator. This certainly adds considerably to the pleasure of riding in French cabs—one can always follow what is happening all over the engine. The only exceptions are electric locomotives, on which nothing worth mentioning ever does happen ! One merely sees results ; for causes one must go to the generating station.

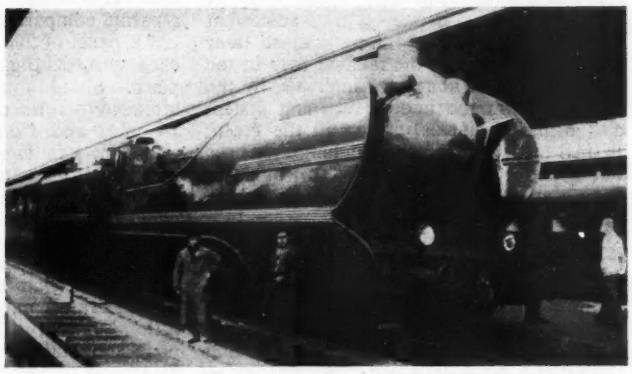


Fig. 51—Four cylinder compound 4-6-0 oil-fired express locomotive

The train left the Gare de l'Est punctually at 8 a.m., accelerating fast on the gentle rise away from the station ; needless to say, though I do so to emphasise it, there was no slipping—there hardly ever is with French locomotives—it must be due to regulators capable of easy initial opening—and careful drivers ! The speed soon reached 70 m.p.h., at which the brakes were tested, and sand fed through the firebox by a long funnel for flue cleaning. There is no ash with oil firing, but a sooty, greasy deposit accumulates in the tubes, calling for scouring at intervals—clear of a station, advisedly. The riding proved very good ; not, of course, quite equal to that of a " Pacific " or " Hudson " in good shape, but good enough for my notes to be read subsequently without a furrowed brow—a good oscillation meter. At 70 m.p.h., on the level, with 35 per cent cut-off in the h.p. cylinders, and about 45 per cent in the l.p., the respective steam chest pressures were 15 hpz. and 3½ hpz—220 lb and 51 lb. The travel of both sets of valve gear is changed by one wheel, though they can be operated separately at will, but it was sometimes difficult for me to judge of the regulator position in the absence of a scale or quadrant —it was probably about ¾ open. With the exception of a slight knock on my—the fireman's—side, apparently an axlebox, the whole of the motion was in perfect shape, despite the engine being forty years old. Boiler pressure can be dismissed from the record, as—the engine being oil fired—it was always right up near popping-off point. The oil is thinned by a coil in the tank before leaving for the burner, which might not have been necessary that day, with the temperature well over 80 deg. Fah. in the shade. The burner is in front of the firebox, under the brick arch ; oil firing had only been fitted to this engine five or six years ago.

Meaux was passed O.T. at 8.30 a.m., 28 miles in 30 min, and soon after there were three short pitches, two up and one down, at 1 in 200, the only gradients worth mentioning in 127 miles. The engine took what curvature there was admirably, with no rolling, nosing or jerky change of direction. Monsieur Calmus said that at speed on the level the drawbar horsepower was about 1165. Chateau-Thierry passed, at 8.55 a.m., 1 min early —58 miles in 55 min, 63·3 m.p.h. The Marne was close alongside here, with its memories of the first war ; a placid stream, meandering among rolling hills and farms—wheat, always wheat, seen on so many of these trips, as usual showing signs of the long-continued drought, but it was wonderfully good, " considering." The line, a " water-level " route, was practically level, and remained so for 100km from Meaux through Chateau-Thierry to Epernay, and the speed was correspondingly so, about 70 m.p.h.; the blow-down was opened every 50km for 20 sec, and sand fed through the firebox. The array of fittings on the boiler head has been mentioned ; they included exhaust pressure and superheater temperature gauges, boiler feed (A.C.F.I.) temperature, Flaman recorder; everything necessary for an engine's salvation and the crew's information was there. I think economy is overdone on British engines, and austerity is becoming a habit—though whether British enginemen could be educated to paying attention to all the refinements which are the rule on French engines is another matter. At any rate, nothing is omitted on French locomotives " because it can be done without."

Epernay, 9.20 a.m., 88 miles in 80 min, 2 min ahead of time, average 66 m.p.h. There had been no signal checks so far ; there seemed less traffic than on a British main line, judging from passing trains, the engine

* The left-hand bystander in Fig. 51.

swinging along at high speed down long straights for many miles on end, the rails converging to a point in infinite distance. Chalons, and a slowing to 30 m.p.h. through the station; 9.36 a.m., 106½ miles in 96 min, 66·6 m.p.h. I noticed a fine new engine shed here, and shortly afterwards the line picked up the Marne again, its cool, shining water looking very tempting this baking hot day, as seen from the none-too-cool cab into which the streamlining brought more warmth than was altogether pleasant. I have noticed this before on streamlined engines, both in Britain and North America.

Near Vitry le Ville a bridge restriction cut the speed to 30 m.p.h.; at such points, when repairs take considerable time, or for relaying, special signals are installed; all are colour-light. Clear of the bridge, the speed rose to the customary 70 to 75 m.p.h., holding steady; it was getting somewhat monotonous, spinning along almost hour after hour, lulled by the muffled roar in the cab, punctuated, at regular intervals, by the "peep" from the audible warning system as "distant" signals, always in the green, flashed by. Our British signalling system is out of date; something of this sort ought to have been the rule long ago, instead of the exception it is at present.

It will be noticed that the side plates are large, but they do not obstruct the look-ahead; the line of sight through the front windows passes between them and the smokebox; it is outside the plates, if one is leaning from the side windows, and looking through the wind-deflecting safety glass strip. I have come across side plates not so well placed that were somewhat in the way from both viewpoints.

Bar le Duc, 10.25 a.m., imposed a lengthy stop; 157·5 miles in 145 min, 65·2 m.p.h.—very good going for an engine built in 1912, and I can safely use my favourite simile—it was working like a sewing machine, with not a complaining sound from anything save that slight axlebox knock, a mere triviality, which wedge adjustment would easily rectify. Leaving Bar le Duc at 10.44 a.m., after a stop of 19 min, with very quick acceleration up a gradient of 1 in 300, we were making well over 60 m.p.h. within a couple of miles on the long climb to Loxéville, which begins immediately clear of the station—possibly getting ready to "rush" the culminating stretch of 6 miles at 1 in 125. No. 230-K242 was working hard here, but the speed never fell below 50 m.p.h. to the summit. The noise in the cab was considerable, and my voice tired; I felt disinclined to say more than was necessary to my friend Calmus, who was so attentive and helpful. The warmth made everyone thirsty, the drought intensified by my well-meant offering of chocolate, which in the end made us drier than ever; any reader travelling in a warm cab is warned about this—don't indulge in chocolate! Cool beer and Perrier, now, that is another story—they were but a happy memory of Bar le Duc.

Farther along, the train was switched to the right-hand metals, the signalling system following suit; a practical people, the French—if the British Western Region method were followed, I suppose the signals would have remained on the left! Sarrebourg, 12.32 p.m., 110 miles from Bar le Duc in 108 min, a trifle slower—the climb to Loxéville had taken toll. Somewhere, though I find no note of just where, but probably after Nancy I travelled between two stops in the train, to find out how the pneumatically-tyred coaches behaved. They ran very quietly, though not quite so smoothly as I had expected, and certainly no better than the beautiful eight-wheeled stock in which I had travelled from Paris to Amiens and Le Mans, as described in previous articles. The equipment is very complete; a separate compartment in the baggage coach has a panel of 200 lamps, connected one to each tyre, lighting up when deflation takes place. Should this happen, the "cripple" is attended to at the next station, the job taking 14 min, and from this compartment the attendant can signal to the cab for slow running, stops and so forth. All this electrical gear must be complicated and costly, and I could not help wondering if the game were really worth the candle. In the coaches the running was smooth and quiet, the sound being somewhat like "the rumble of a distant drum," and they seemed to bounce a little at times; there was a curious feeling of lack of stability—it is difficult to describe it exactly—particularly on curves, rather like a car running on soft tyres. It was different from a steel-shod coach, and I was not quite sure whether I liked it. Such is the result of custom, no doubt; I was a little dubious about it all! I took the opportunity to visit the diner for light refreshment, chiefly liquid; it seated four-a-side; the seating, upholstered with sorbo-rubber, was roomy in all directions, including about one's knees, the decoration scheme being simple and pleasing; there was central fluorescent lighting and (I think) air-conditioning. Altogether the train seemed an interesting and ingenious experiment, well worked out, but candidly, I do not think pneumatic-tyred trains are ever likely to become common. Later, I enquired from an official of another Division of the S.N.C.F., not directly concerned with the train, whether it was really worth-while—his "Non!" was emphatic, so that was that. Steel is evidently good enough for him—and for me.

Back in the cab, I was annoyed at finding myself drowsier than ever and the *mécanicien*, good fellow, noticing my occasionally drooping eyelids, became concerned, and asked Calmus to enquire if I were tired? I said no, not tired, merely a bit sleepy—I had been on the go the best part of thirty-six hours, with very little rest the night before, so naturally, at my age, I was beginning to feel the effects—Calmus translated. His face expressing astonishment and incredulity, the *mécanicien* threw up his hands—"Soixante-dix? C'est impossible—impossible—Je ne le croix pas—il plaisant!" Assured it was not only possible, but undeniable, he turned to Calmus with an aside that sounded like: "Voila pourquoi l'Angleterre n'est pas rendue à Hitler en 1940!" Alas, I had to confess absence from England during that critical period, thus having nothing to do with Britain's resistance movement, but this dual unmasking only increased the crew's goodwill; both tact and firmness were necessary to keep out of the fireman's seat, which he almost implored me to accept. The toll of the years—a complaint for which "not even poppy, mandragora, nor all the drowsy syrups of the East" more inexorably demand payment. But I still refuse to settle the account until I feel like doing so!

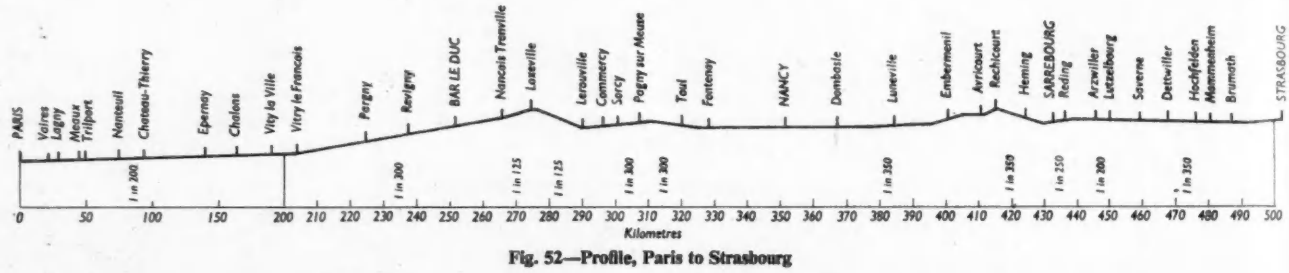


Fig. 52—Profile, Paris to Strasbourg

By this time we were among the Vosges Mountains; the character of the country had quite changed, farmlands having disappeared, their place taken by fir-clad hills and rushing streams; no long straights now, but plenty of curvature. A long tunnel was negotiated, the first of the day, and with the possible exception of the one at Blaisy-bas, near Dijon, the longest I had so far met with in France. It was followed by a succession of tunnels—we were scarcely clear of one before diving into another—yet the engine kept up its steady 70/75 m.p.h. to Saverne, passed at 12.46 p.m., the last 17 miles having been covered in 14 min, 73 m.p.h. Both enginemen were exceptionally keen fellows, absorbed in their jobs, never relaxing—I have seldom seen greater concentration in the cab. Leaving the Vosges behind, farms again appeared, and station names showed the German border could not be far away—Lutzelbourg, Dettweiller, Hochfelden, Mommenheim—and the gradient had been steadily falling from Sarrebourg. We were nearing Strasbourg now, running through dead flat country, and in my heart I was not sorry, for though the whole run from Paris on this noble old veteran had been most interesting, I had had nearly enough—the last couple of days had been tough. The sight of the towering spire of Strasbourg Cathedral was welcome; large engine-sheds, multiplying tracks and other concomitant signs of approach to a large city and railway centre—rest was near! No. 230-K242 came to a stand in the station at 1.14 p.m.—of course, 1 min early—the 312 miles from Paris having been covered in 314 min, inclusive of several stops, that at Bar le Duc having been of 19 min. Deducting this one, but not the others—because I forgot to note them—the time had been 295 min, an average of 63·5 m.p.h., the fastest run I have ever done over such a distance; the actual figure was probably about 65. The nearest parallel was with the "Coronation Scot" before the war, on a modern Stanier "Pacific," hauling 300 tons from Carlisle to Euston,

299 miles non-stop at 61 m.p.h. But the French engine was forty years old—the Stanier only four. A really fine performance by an engine that in other countries might have been scrapped—yet it ran like a sewing-machine (excuse me !)

Like all these good couriers, Monsieur Calmus was anxious to make this excursion pleasant for me, suggesting that after lunch we take a stroll about the city, and up the cathedral spire ! I had to beg off. " Please, *mon cher ami*, not this afternoon ! Sleep, sleep—I *must* have some sleep ! This evening, by all means, I shall be delighted—if you will wake me up at 7, or I shall probably sleep the clock round." With quick understanding and apologies, he piloted me to what I believe was a railwaymen's hostel, where, he said, we should get just as good food as at the hotel, at half the cost. He was right ; it was a delightful lunch, and once again I marked the contrast with Britain, where in a similar environment we should almost inevitably have found only the national dish on the menu, the Fish-and-Chips of Old England. *Here* we sat down to a tasteful meal of several courses, perfectly cooked and served, with appropriate wines, in a spotless, homely dining-room, and were in no hurry to leave. Much as I love my native land, and hate to find fault with it, impatience with its shortcomings sometimes plays hob with my affection—why on earth cannot we learn to cook and dine in a civilised way ? This restaurant was neither a Trocadero nor Savoy —it was a simple railwaymen's café, yet it was a pleasure to dine in it. In England, in a corresponding eating-house, one would probably get, not so much a meal as a gastronomic insult, crude and unappetising—a culinary catastrophe, the sort of thing that ruins body and soul alike, and is the cause of half the crime in the country. It is high time we learned to do better, and the French can teach us—and how to build and run locomotives ! If, of course, union rules will permit.

A charming city, Strasbourg, of broad streets, fine shops, imposing stone buildings, both old and new, and an air of dignified decorum, without the hectic rush and glitter of Paris, its quiet, restful atmosphere exactly what I needed after recent strenuous days in the cab. The day ended very late, after an evening spent wandering about the fascinating city with Monsieur Calmus, talking, talking—with an occasional " rest-and-be-thankful " at kerbside cafés—not of locomotives so much as Shakespeare. Calmus was another S.N.C.F. friend who had learned much of his excellent English from the works of the Immortal Bard—Monsieur Fillon was the other. It was with embarrassment I found they knew more about Shakespeare than I did, and both had specialised in " Hamlet," which I " studied " at school and have religiously avoided ever since. " And so to bed, not fox'd, but well content, having busied myself nigh on two-score hours." I have very pleasant memories of Strasbourg, and mean to visit it again—and eat once more at that railwaymen's restaurant ! *A bas les Fish-and-Chips !*

(To be continued)

WATSON HOUSE CENTRE.—The Gas Council, by agreement with the North Thames Gas Board, is assuming responsibility for the Watson House Centre, which will be administered on behalf of the Council by the Board. Mr. L. W. Andrew, who has been senior technical officer at the Centre, has been appointed its director. The Watson House Centre deals with the design and performance of appliances for the combustion of gas and coke in domestic, commercial, industrial and public buildings. An important function of the Centre is the testing and approval of appliances.

German Industries Fair, Hanover

No. III—(*Concluded from page 755, May 21st*)

ARDELTWERKE G.M.B.H. WILHELMSHAVEN

A RAILWAY crane of unusual interest was shown on the stand of Fried Krupp, by the Ardeltwerke G.m.b.H. of Wilhelmshaven. It is illustrated in Fig. 17. The crane has been designed for track laying and maintenance, and the laying not only of straight lines but also crossings and points. The largest assembled length of track which can be lifted (see Fig. 17), has a length of 18m, and this can be laid or lifted at a distance of 9·5m in front of the buffer beam, or 13·4m from the centre turning axis of the crane. The buffer assembly is so designed that it can be swung out from the buffer beam in order to provide additional lifting length.

The jib of the crane is shaped so that it can operate below bridges or in tunnels, and the crane can carry out track repairing operations below the overhead equipment on electrified lines. The crane can also be utilised for general civil engineering work on railways.

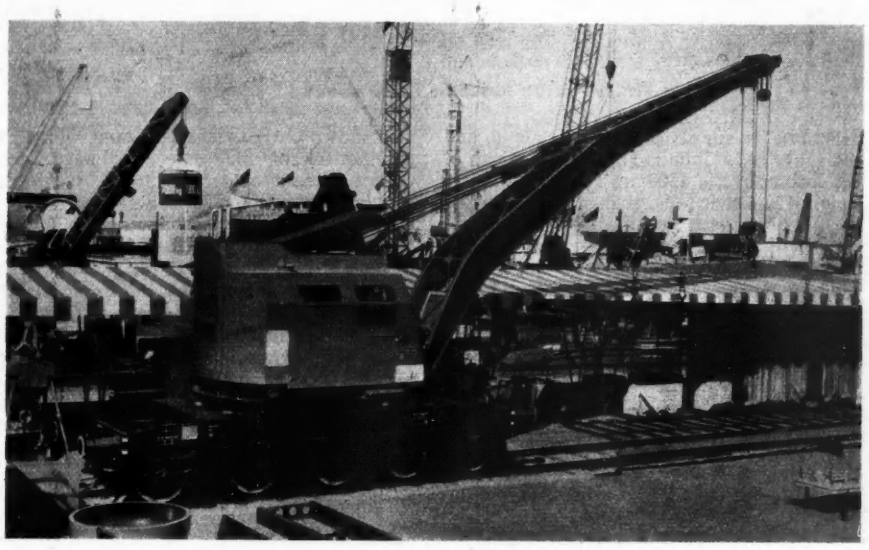


Fig. 17—Six-ton diesel-driven track laying crane—Ardeltwerke

In order to keep within the prescribed normal loading for the axles, five-axled mounting was required for the crane, which weighs about 70 metric tons. There are two bogies, one of them with three axles, and the other with two axles. The forward and reverse drive of the crane is transmitted to each axle, and the designed working speed is about 5km per hour, which enables the crane to be used for shunting wagons if desired. By disconnecting the driving pinion the crane can be hauled with a train at speeds up to 80km per hour, as it is equipped with standard railway springing and complete compressed air brakes. The lowered jib is carried on a special forward carriage, and when so arranged, the crane can quite easily follow all normal curves.

In order to enable the crane to take its part in laying track ballast, and earth-moving operations, it is provided with a four-rope grab, and can lift 3·5 tons at a radius of 13·4m. The crane is driven by a new type of air-cooled diesel engine working on the four-stroke principle with six cylinders. The engine also drives an electric motor through a flexible coupling and a gearbox and also a twin cylinder air compressor. All the movements of the crane are controlled by compressed air, and the simple controls and the conveniently arranged levers eliminate fatigue to a large degree. The driving cab in which the controls are placed is built well forward and its windows give a clear view of the work. Westinghouse fittings are employed for the air control system. The crane can be used without side supports and it is only necessary to block the axle springs.

The lifting loads for a full 360 deg. swing are 6 metric tons at a radius of 9m and 10 tons at a radius of 6m. For lifts in the direction of the lines on which the crane is standing, in accordance with the position of the jib over the two or three axles bogie, the load figures are 6 tons at a radius of 13·4m and for slewing from 22 to 31 deg., while from 14 to 25 deg., 10 tons can be lifted at a radius of 9·5m. The length of the crane over the buffers is 9040mm.

FRIED KRUPP LOCOMOTIVFABRIK

A prominent exhibit on the Krupp stand was the electric locomotive illustrated in Fig. 18, which is one of sixteen built by Krupps and the A.E.G. for the Rheinische A.G. für Braunkohlenbergbau und Brikettfabrication, and the Niederrheinische Braunkohlen werke at Frimmersdorf. The locomotive, an example of which we were able to inspect under construction during our recent visit to Essen, has a specially built-out cab, in order to allow the driver to look along the very wide trucks which are employed in the brown coal industry. The complete electrical equipment was supplied by the Allgemeine Elektricitäts Gesellschaft and the mechanical construction by the Krupp Locomotivfabrik, Essen.

The general arrangement of the locomotive is B_0–B_0 with two bogies and four driven axles. The total length of the locomotive over the buffers is 14,500mm, the total wheelbase is 9500mm, and the bogie wheelbase

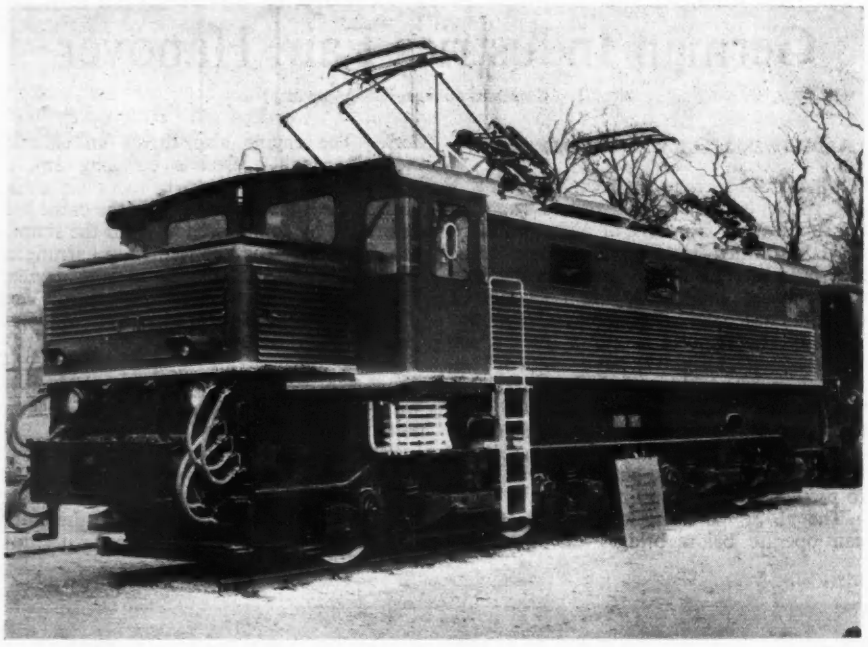


Fig. 18—Electric locomotive for the brown coal industry

3100mm; the wheel diameter is 1120mm, and the gauge is 1435mm. The greatest width of the locomotive is 4300mm and the adhesive weight 120 metric tons, giving an axle loading of 30 tons.

Current is taken from the overhead lines at 1000V a.c., single-phase and at 50 c/s. In the locomotive is a rotary converter comprising a synchronous motor driving a d.c. generator. The auxiliary machinery of this unit comprises a built-on exciter for the synchronous motor and a starting motor. The 750V d.c. current generated by the converter drives a motor on the axle of each bogie through double-reduction gearing with a reduction ratio of 5643 : 1. The four driving motors have each a designed output of 370kW, giving a total driving power of 1480kV with 750V d.c. current. Other electrical equipment includes amplidyne control, electrical axle load control, electrical braking, and the usual safety starting devices. The maximum effort is 38,000 kg at a speed of 24·4km per hour, and the locomotive has a maximum speed of 70km per hour. Similar electric locomotives for the brown coal industry, also with A.E.G. electrical equipment, have been built by Henschel and Sohn of Kassel, and one of these locomotives was also shown on the Henschel stand. Further locomotives of the same type have been built for the brown coal mines by Krauss Maffei of Munich.

Another interesting exhibit on the Krupp stand was the compressed air "rotary piston" turbine specially designed for mining work which is manufactured by the Fried Krupp Essener Maschinenbau Essen, and is made in powers from 50 h.p. up to 200 h.p. In Fig. 19 we show a section through the prime mover. The compressed air enters it from the top and is distributed to the turbines on either side by the central rotating piston valve, which has ports to deliver the air into the pressure space in the annulus formed by the runners which are shown to the right near the bottom, and to the left near the top, approaching the exhaust part of the stroke. The air charge is delivered at constant pressure during the first part and then expands freely until the exhaust port opens.

The piston valve, the two turbine wheels and their runners, run synchronously and the turbine has a speed of 3000 r.p.m., which is reduced to 1500 r.p.m. by reduction gearing, as shown in Fig. 20. Labyrinth packings on all parts do away with oil lubrication and the compressed air is kept free from oil. The turbine is claimed to have a long life, as the wear is negligible. The firm of Fried Krupp is represented in the United Kingdom by J. M. J. Maus, Ltd., of 35, New Broad Street, London, E.C.2.

Demag Aktiengesellschaft

On its main stand the Demag Aktiengesellschaft, of Duisburg, showed a model of the new combined Thomas and Siemens-Martin steel works, which it has recently completed for the Montan Company "Sollac" in Serémange-Lorraine, in conjunction with French, Saar and other German firms. This model graphically demonstrated the full mechanisation of the steel making process. As an example of such work there was shown an elevating platform (see Fig. 21), which will be employed in connection with the reconstruction of the Salzgitter steel works for the relining of the 50-ton converters. As the illustration clearly indicates, the moving platform is supported on three pairs of "lazy tongs." These each have semi-circular lower links actuated by a motor-driven pinion to extend or retract the lattice

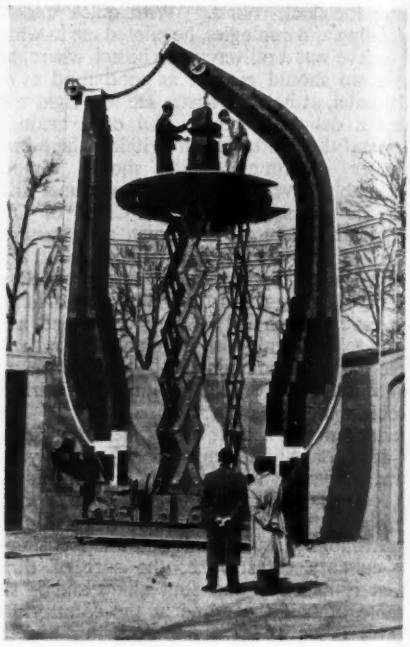


Fig. 21—Platform elevator for relining steel converter —Demag

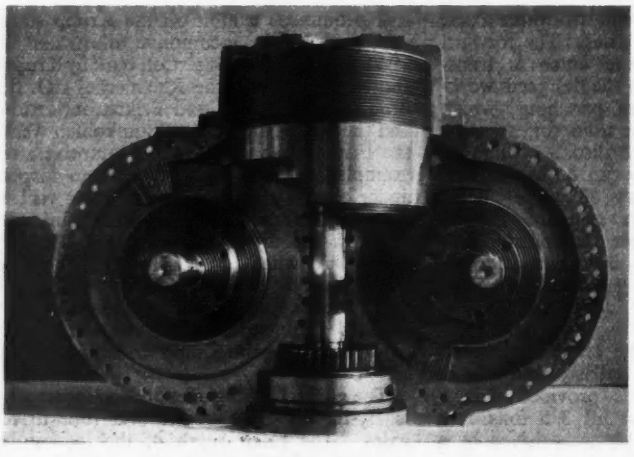


Fig. 19—Section through compressed air "piston turbine"

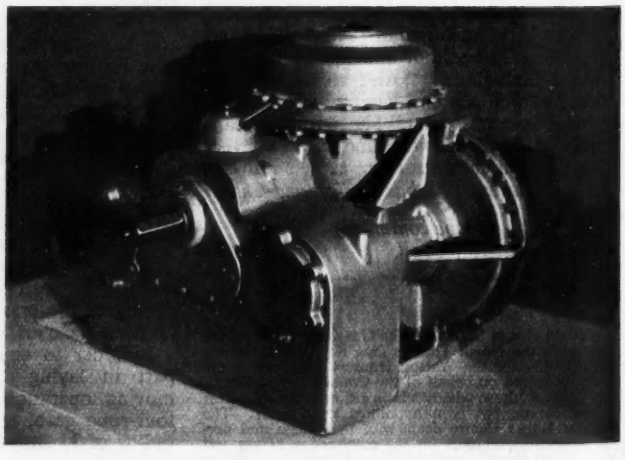


Fig. 20—General view of compressed air "piston turbine" with gearing

members for raising or lowering the top platform on which the builders work. A side crane is also provided to lift and handle the building materials. The two outside members outline to full scale the shape of the converter within which the elevating platform will be erected.

The Demag Baggerfabrik G.m.b.H., of Dusseldorf-Benrath, showed new pieces of plant, one of which was a universal excavator with a jib 33·6m in length. This machine was arranged as a dragline excavator with a 2·5 cubic yard bucket. It was designed for work on sites with no power supply and where the machine must cover long distances under its own power. The diesel-electric machinery is accommodated in rear sections of the cabin, and the controls are housed in the forward part. Power is

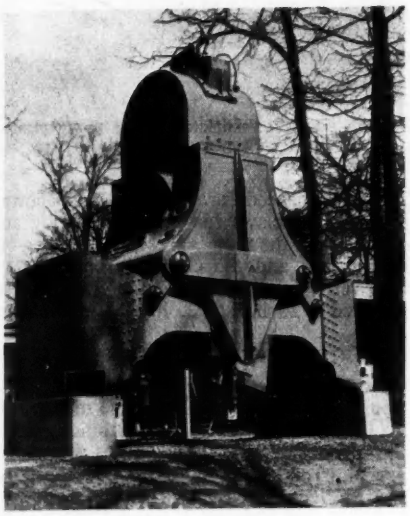


Fig. 22—18-ton capacity grab for iron ore—Demag

supplied by a six-cylinder Mercedes-Benz four-stroke, supercharged engine with a bore of 75mm and a stroke of 205mm. It has a continuous rating of 415 h.p. at 1500 r.p.m. and a maximum rating of 500 h.p. The engine drives a Garbe-Lahmeyer three-phase synchronous alternator, which generates 500V, 50 c/s current with a power factor of 0·8 and an output of 350kVA. In the machine house a small overhead crane is provided for erection and overhaul of the equipment. Another new design of universal excavator, the first of a new series, differs from previous models in its appearance and the layout of the machinery. The boom is of welded box section and in it the dipper arm is pivoted in a central aperture. Instead of the usual rack and pinion, a roller chain boom drive is used to give smooth and silent operation. The bucket crowding and return motions are taken from the hoisting drum shaft, but are independent of the bucket lifting motion. The return motion is twice the rate of the crowding motion, which gives a considerable increase in operating speed. All the controls are pneumatically operated, air being supplied by a twin-cylinder air compressor driven from the excavator engine. The operator's cabin on the left of the boom is separated from the machinery space and the operator is isolated from any heat, exhaust gas or engine noise. The controls are very simple and comprise two short levers and two pedals, which actuate the valves for all working motions. By arranging the machinery behind the centre of gravity of the machine it has been possible to reduce the counterweight used to 1·5 tons.

An interesting exhibit staged by the Demag Greiferfabrik G.m.b.H., of Duisburg-Hamborn, was the large 18-ton grab, which forms part of the equipment supplied by Demag for the Luossavaara-Kiirunavaara A.B., of Narvik, for the transport of Swedish iron ore at the rate of 8000 tons per hour, and shown in Fig. 22.

Demag Aktiengesellschaft is represented in this country by D.M.M. (Machinery), Ltd., of 66, Victoria Street, London, S.W.1.

Menck and Hambrock G.m.b.H.

The principal exhibit shown by Menck and Hambrock G.m.b.H., of Hamburg-Altona, was one of the firm's new three-motor all-electric shovels, which have been designed for use in quarries, and are made in two sizes, with bucket capacities of 4¼ and 6 cubic yards respectively. Fig. 23 shows the smaller model at Hanover. The machine is carried on wide crawler tracks, which are entirely enclosed, yet easily maintained, and its ground pressure when travelling is only 25·6 lb per square inch. The travelling gear is driven by the hoisting motor and is reversible, and the two tracks are independently operated from the driving position. The track design embodies a horizontal thrust bearing or thrust equaliser, which keeps the rollers from running on their edges.

The sheet steel cabin is mounted on the revolving frame, and for field work where blasting is used a reinforced construction is used for protection against stray splinters. The driving controls are all pneumatically operated by finger pressure levers, compressed air for this purpose being supplied by an air-cooled compressor in the machinery space. The hoisting drum is engaged by a pneumatically operated brake band clutch, which slips when overloaded, and the brake gear is pedal operated. The hoisting motor is of 240 h.p.

The boom is of welded box section and by using two dipper sticks the splitting of the main boom is avoided. The dipper stick guide plates attached to the sides of the boom have replaceable wearing plates. The boom is raised and lowered by a multi-part rope system passing over the *A* frame on the top of the revolving frame. This rope system is attached to a special boom hoisting drum, actuated by bringing a gear wheel into mesh with the hoisting gear. The drum is held by a continuously applied brake, which can only be released for raising or lowering operations and thus prevents the dropping of the boom, by an error in operation. The slewing motor is of 104 h.p. The crowding gear which is worked by a 91 h.p. motor, has a slip clutch and pneumatic automatic brake with an interrupter which prevents the excessive advancing of the bucket. The bucket is lifted by a four-part rope system with large sheaves. Its long teeth assist when working with soft or blasted materials, and the bucket door has a welded box section latch. Through its control lever, bucket door opening can be adjusted so that small size materials can be unloaded first, and then bigger sizes deposited on top of the smaller material, which has a cushioning effect.

The three electric motors used for the hoisting and travelling, the slewing and crowding motions are all fitted with resistance control, slip resistances being superimposed in the circuits to keep the maximum torque within permissible limits, and give a smooth characteristic. The working voltage of the excavator can be from 500V up to 6000V d.c., and for three-phase working a special transformer is fitted.

Jlo Werke G.m.b.H.

An interesting example of a single-wheel petrol engine driven truck mover was demonstrated during the Fair by Jlo Werke G.m.b.H. Pinneberg, Hamburg, and Fig. 24 shows the machine in action. It is designed to move wagons up to 100 tons in weight on level tracks and 30 tons of wagons on gradients of 1 in 100. On sharp curves of 35m radius it will also deal with wagons up to 30 tons in weight. The pushing or pulling arm is extensible by means of a screw thread and can be locked in any desired position. The arm has also a hook attachment for securing the machine to the truck or wagon. The normal reach of the pushing arm is 750mm and the maximum reach 960mm, but special lengths can be supplied. The 6 h.p. (3000 r.p.m.) engine driving the wheel has a Bosch flywheel magneto and Bosch ignition. When shunting oil tank wagons, explosion proof ignition and carburetter systems are supplied. The engine has three speeds, which are automatically controlled from the wheel and handle controls. For wheeling the machine over lines and sleepers a small forward supporting wheel is fitted and a tubular strut extension can be lowered to retain the handles in the horizontal position. The engine is

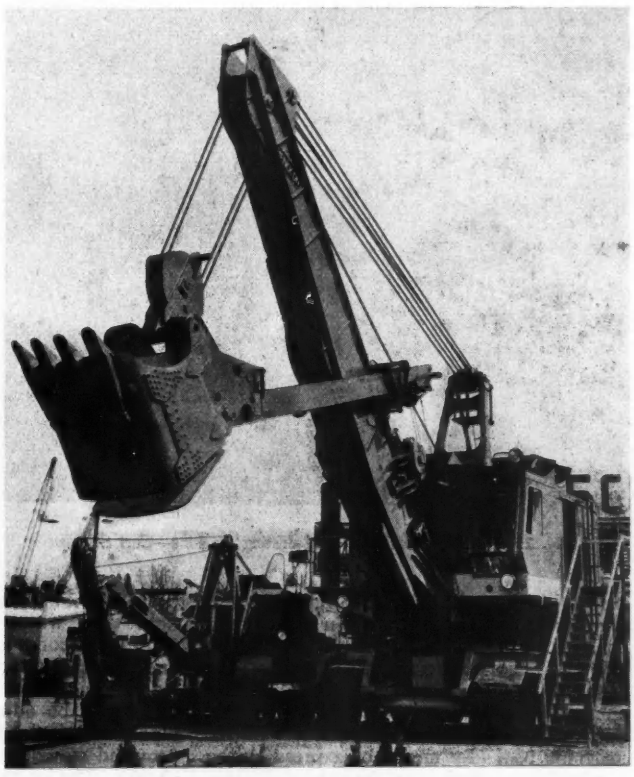


Fig. 23—Heavy shovel for quarry work—Menck and Hambrock

fully enclosed in the casing above the rubber-tyred driving wheel, and this casing also carries the adjustable pushing member and the fuel tank. The guiding handles and frame

Fig. 24—Petrol engine-driven single-wheel truck mover—Jlo Werke

are mounted on a circular ring around the casing and are so designed that they can be swung through 90 deg., so as to allow the machine to be operated from the side.

Carl Schenck G.m.b.H.

Carl Schenck G.m.b.H., of Darmstadt, exhibited a wide range of balancing machines especially for the automobile industry. New developments this year included the use of isotropic bearings to give increased stiffness and the vector method of measuring with direct readings. The two examples we have chosen will serve to indicate the general trend of development. In the combined balancing and drilling machine "AZ 43 B," shown in Fig. 25, flywheel rims and similar circular masses can be balanced in weights up to 150 kg. The position and amount of unbalance is determined by the wattmeter method, in two planes, and can be read on the instrument table shown to the left of the machine bed. By means of a press button the drilling machine is then brought into action and the surplus material removed to bring the disc in balance. Another machine which attracted interest was that which has been constructed for the balancing of automobile wheels and brake drums. In this machine, the part to be balanced is supported on a shaft and balance can be established in two planes with great accuracy. The balancing weights can be applied on either side of the wheel and the balancing operation only takes about two minutes to complete.

Pleuger and Co.

The firm of Pleuger and Co., of Hamburg-Wandsbeck, showed a wide range of submersible pumps and examples of the "Active" rubber for ships. This firm's new "Ventimotor" wind power plant (see Fig. 27) was shown for the first time at Hanover, and before being sent to the Fair this unit was employed on estate drainage work. The wind wheel has a diameter of about 3m and is made of corrosion-resistant light alloy, the steering vane and the upper parts of the supporting tower being of welded construction. It is designed to operate at mast heights from 8m to 12m, according to the most favourable wind conditions. The plant incorporates means of mechanical transmission from the wind wheel to a submersible pump or to an a.c. or d.c. generator at ground level for operating electrically driven pumps or storage battery charging.

Dinglerwerke Aktiengesellschaft

On the stand of the Dinglerwerke Aktiengesellschaft, of Zweibrüken, there was shown a new type of horizontal bandsaw, shown in Fig. 26, which has been designed for the most economical cutting up of a log and a minimum loss by saw cuts which are only $\frac{1}{16}$in to $\frac{5}{16}$in thick. The two wheels carrying the saw blade are mounted on a cross beam sliding on the vertical guide members of the machine. The motor is supported on this cross beam and the movement of the beam is arranged for hand or motor operation. The wheels have a speed of about 130ft per second, and one is a driving wheel and the other an idler, both being supported on conical roller bearings. The driving wheel can be adjusted to tension the saw blade, while a flexible straining device is also provided to deal with irregularities and shocks. The log carriage is driven electrically in both directions and the variable travelling and return speeds are stepless. As shown, four sets of claws for gripping the log are provided on the table. The carriage runs on strong rails and the clearance between the two vertical members is 1m. The power required is 20 h.p. to 25 h.p. at 1450 r.p.m.

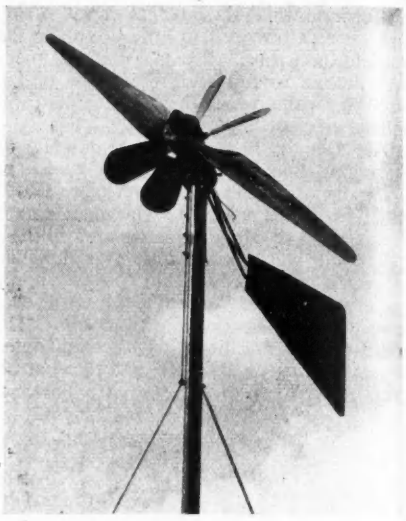


Fig. 27—VO.5 "Ventimotor" wind power plant—Pleuger and Co.

The International Container Exhibition

No account of the Hanover Fair of 1954 would be complete without some mention of the International Container Exhibition, which was arranged by Dr.-Ing. Hans Christoph Seebohm, the Bundesminister of Transport, and M. Jean Levy, President of the Bureau International des Containers, 35, Cours Albert 1st, Paris, 8e. The exhibition was well supported by the Bundesbahn and the railway companies of Belgium, France, Great Britain, the Netherlands, Sweden, and Switzerland. The firms participating showed their exhibits in two halls and on railway lines outside.

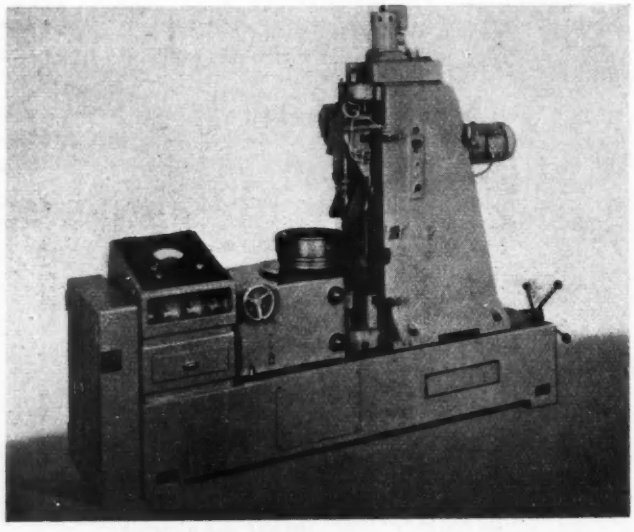


Fig. 25—Combined balancing and drilling machine—Carl Schenck

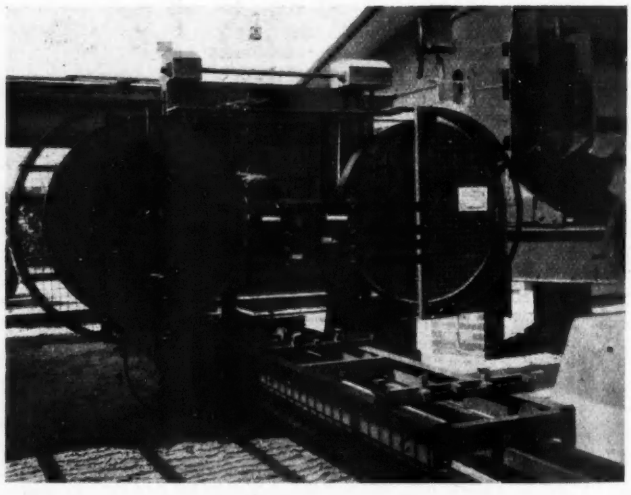


Fig. 26—Horgard log band saw—Dinglerwerke

Institution of Industrial Safety Officers.—At the recent annual general meeting, in Scarborough of the Institution of Industrial Safety Officers, Mr. A. G. Palmer, of the North Thames Gas Board, succeeded Mr. H. R. Payne as president. It was stated that the membership of the Institution is now 465.

Calculation of Transient Heating in Single-Core Cable Dielectric

By H. GOLDENBERG, M.Sc., A.R.C.S.*

The transient temperatures at different points of the dielectric of a single-core cable when a finite amount of heat is suddenly supplied to the core is shown to be obtainable by means of a resistance capacitance ladder network analogue. For sufficiently few stages in this ladder network the standard Laplace or Heaviside method is used to obtain the required transient temperatures. The process is illustrated by comparison of the transient temperatures at equally spaced points in the dielectric from core to sheath for 0·06 square inch, 11kV and 660V single-core cables in air.

THE determination of the transient temperature at any point in the dielectric of a single-core cable when a finite amount of heat is suddenly supplied to the core does not so far appear to have been successfully carried out, except in the limited case for periods before the rise in temperature of the lead sheath becomes appreciable.[1] It is not readily susceptible to analytical treatment, and the available graphical and numerical methods in this type of problem are both long and tedious.

The present account shows that the boundary conditions of the above problem are such that it may readily be solved by means of a resistance capacitance ladder network analogue, provided that the sheath thermal capacity/unit length is adjusted to take account of the surrounding medium. This analogue has been described principally, although on somewhat differing bases, in papers by Jackson and others,[2, 3] and Paschkis[4]; the former analogue is based on an identity of approximate equations and the latter on a Bessel cable analogy, but both methods are more accurate than the available data concerning the thermal quantities involved.

Consequently, it now becomes the case that the above problem may be solved electrically or, should there be sufficiently few stages in the resistance capacitance ladder network, by the direct application of operational methods. This is illustrated by means of a comparison of the transient temperatures at equally spaced points in the dielectric for single-core 0·06 square inch, 11kV and 660V cables.

The analogue used in the present account is that of Jackson and others as applied to heat conduction problems in a hollow cylinder. This is considered by the writer to be somewhat simpler in application to the present problem than the corresponding analogue of Paschkis.

Thermal Problem and Electric Analogue

The initial assumption is made that the core and sheath each possess infinite thermal conductivity, but finite thermal capacity. With this assumption the temperature $\bar{\theta}$ at time t at a point distant r from the axis of the cable is given by the radial heat conduction equation :

$$\frac{1}{D}\frac{\partial\bar{\theta}}{\partial t}=\frac{\partial^2\bar{\theta}}{\partial r^2}+\frac{1}{r}\frac{\partial\bar{\theta}}{\partial r} \quad a<r<b \quad . \quad . \quad . \quad (1)$$

subject to the boundary conditions :

$$\left.\begin{aligned} C_c\frac{\partial\bar{\theta}}{\partial t}&=2\pi ak\frac{\partial\bar{\theta}}{\partial r} && \text{when } r=a\\ C_s\frac{\partial\bar{\theta}}{\partial t}&=-2\pi bk\frac{\partial\bar{\theta}}{\partial r} && \text{when } r=b \end{aligned}\right\} \text{for } t>0$$

$$\left.\begin{aligned} \bar{\theta}&=\theta_1+\theta_0 \text{ when } r=a\\ \bar{\theta}&=\theta_1 \text{ when } a<r<b \end{aligned}\right\} \text{for } t=0$$

where

D = thermal diffusivity of dielectric.
k = thermal conductivity of dielectric.
C_c = thermal capacity per unit length of core.
C_s = thermal capacity per unit length of sheath.
a = radius of core.
b = inner radius of sheath.

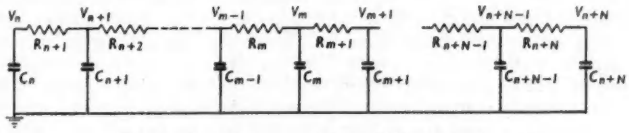


Fig. 1—Resistance capacitance ladder network

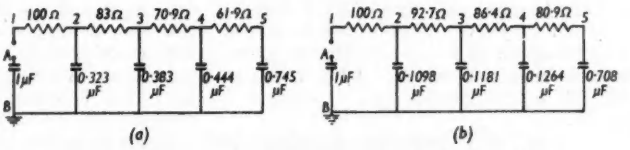


Fig. 2—Ladder network representation for 0·06in square inch, 11kV, and 660V single-core cables

Denoting $\theta=\bar{\theta}-\theta_1$, we need the solution of

$$\frac{1}{D}\frac{\partial\theta}{\partial t}=\frac{\partial^2\theta}{\partial r^2}+\frac{1}{r}\frac{\partial\theta}{\partial r} \quad a<r<b \quad . \quad . \quad . \quad (2)$$

subject to the boundary conditions :

$$\left.\begin{aligned} C_c\frac{\partial\theta}{\partial t}&=2\pi ak\frac{\partial\theta}{\partial r} && \text{when } r=a\\ C_s\frac{\partial\theta}{\partial t}&=-2\pi bk\frac{\partial\theta}{\partial r} && \text{when } r=b \end{aligned}\right\} \text{for } t>0$$

$$. \quad . \quad . \quad . \quad . \quad . \quad (2a)$$

$$\left.\begin{aligned} \theta&=\theta_0 \quad \text{when } r=a\\ \theta&=0 \text{ when } a<r<b \end{aligned}\right\} \text{for } t=0 \quad . \quad (2b)$$

Let the hollow cylinder containing the dielectric be considered as divided into N concentric shells each of thickness δr, so that $\delta r=b-a/N$. Then if P, Q and R are three points at radii $(m-1)\delta r$, $m\delta r$ and $(m+1)\delta r$ respectively from the cable axis, it has been shown by Jackson and others[2A] that for points Q not on the axis, and with θ_m=temperature at radius $m\delta r$, the approximate recurrence relation corresponding to (2) is :

$$(2m+1)\theta_{m+1}-\left[4m+\frac{2m(\delta r)^2}{D}\frac{d}{dt}\right]\theta_m+(2m-1)\theta_{m-1}=0 \quad . \quad . \quad . \quad . \quad (3)$$

Denoting $a=n\delta r$, where n need not necessarily be an integer, this recurrence relation holds for $m=n+1, n+2 \ldots n+N-1$.

With the approximations

$$\left(\frac{\partial\theta}{\partial r}\right)_{r=a}=\frac{\theta_{n+1}-\theta_n}{\delta r}$$

and

$$\left(\frac{\partial\theta}{\partial r}\right)_{r=b}=\frac{\theta_{n+N}-\theta_{n+N-1}}{\delta r}$$

the boundary conditions at $r=a$ and $r=b$ in (2a) become respectively :

$$\left.\begin{aligned} \frac{2\pi ak}{\delta r}\theta_{n+1}&=\left[\frac{2\pi ak}{\delta r}+C_c\frac{d}{dt}\right]\theta_n \quad \text{when } r=a\\ \frac{2\pi bk}{\delta r}\theta_{n+N-1}&=\left[\frac{2\pi bk}{\delta r}+C_s\frac{d}{dt}\right]\theta_{n+N} \quad \text{when } r=b \end{aligned}\right\} \text{for } t>0$$

$$. \quad . \quad . \quad . \quad . \quad . \quad (3a)$$

Consider the following resistance capacitance ladder network (Fig. 1).

Denoting $S_m=1/R_m$, it has been shown by Jackson and others[2B] that

$$S_{m+1}V_{m+1}-\left[S_m+S_{m+1}+C_m\frac{d}{dT}\right]V_m+S_mV_{m-1}=0 \quad . \quad . \quad . \quad (4)$$

At the initial and final ends of this ladder network we have respectively :

$$\left.\begin{aligned} \frac{V_{n+1}}{R_{n+1}}&=\left[\frac{1}{R_{n+1}}+C_n\frac{d}{dT}\right]V_n\\ \frac{V_{n+N-1}}{R_{n+N}}&=\left[\frac{1}{R_{n+N}}+C_{n+N}\frac{d}{dT}\right]V_{n+N} \end{aligned}\right\} \quad . \quad (4a)$$

A comparison of equations (3) and (4) shows that the two equations are of the same form, and may be made identical by choosing :

$$\frac{S_{m+1}}{2m+1}=\frac{S_m+S_{m+1}}{4m}=\frac{S_m}{2m-1}=\frac{DC_m}{2m(\delta r)^2}\cdot\frac{t}{T} \quad . \quad (5)$$

and $V_m=\lambda\theta_m$, where λ is an arbitrary constant . . . . . (6)

The first two equations in (5) are satisfied by making

$$S_m=\frac{2m-1}{\mu} \quad \text{or} \quad R_m=\frac{\mu}{2m-1}$$

where μ is any constant

and $m=n+1, n+2, \ldots n+N$. (7)

The last equation in (5) is then satisfied by taking

$$C_m=\left[\frac{2(\delta r)^2}{D\mu}\cdot\frac{T}{t}\right]\cdot m,$$

where $m=n+1, n+2, \ldots n+N-1$. (8)

A similar comparison of the boundary conditions in the heat and electrical problems of equations (3a) and (4a) respectively shows that the corresponding boundary conditions may be made identical by choosing :

$$\left.\begin{aligned} C_n&=\frac{(\delta r)}{2\pi akR_{n+1}}\left(\frac{T}{t}\right)\cdot C_c\\ C_{n+N}&=\frac{(\delta r)}{2\pi bkR_{n+N}}\left(\frac{T}{t}\right)\cdot C_s \end{aligned}\right\} \quad . \quad . \quad (9)$$

The boundary conditions of (2b) for the heat problem still remain to be satisfied in the electrical representation. This is achieved by initially charging the capacitance C_n to a potential $\lambda\theta_0$, whilst the remaining condensers are uncharged, and recording the transient voltages V_n, $V_{n+1} \ldots V_{n+N}$ as the capacitance C_n discharges through the ladder network. On division of these transient voltages by λ and the addition to the result of θ_1, we have the transient temperatures at equally spaced points in the dielectric of the cable ranging from the core to the sheath.

Equations (7), (8) and (9) then give the required values of the components in the resistance capacitance ladder in terms of

* Electrical Research Association.

arbitrary constants μ and T/t and also in terms of N, the number of concentric shells into which the dielectric is divided.

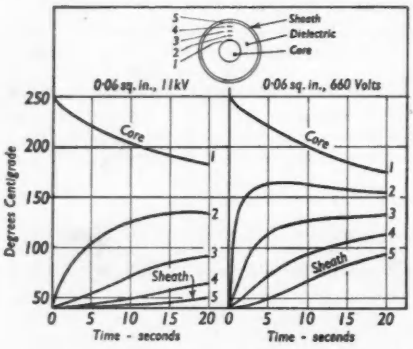
The arbitrary constants λ, μ and T/t are chosen so that the resistances, capacitances, their corresponding time constants and the initial charge on the capacitance C_n are of convenient magnitudes. Further, there is no useful purpose served by dividing the dielectric into a larger number of concentric shells than is necessary considering the uncertainty of much of the thermal data involved. Four concentric shells appear to be sufficient for the present type of problem.[2c]

Example

The relevant constants for single-core 0·06 square inch, 11kV and 660V cables are given in Table I below.

The dimensions of core and sheath have been taken from a British Standards publication,[5] whilst the thermal constants have largely been taken from an E.R.A. report.[6]

The temperatures θ_1 and θ_0 have been taken as 40 deg. and 210 deg. Cent. respectively, whilst the convenient values of λ, μ and T/t which have been chosen are 0·009524, 974 and $3·62\times10^{-6}$ respectively, for the 11kV cable, and 0·009524, 2536 and $7·37\times10^{-6}$ respectively for the 660V cable. With these values for the arbitrary constants, the corresponding electrical circuits are given in Fig. 2. In each case the condenser between AB would be charged to 2V, and discharged through the remainder of the ladder network, initially passive. The consequent transient voltages at the points 1, 2, 3, 4 and 5 in each network would then be recorded, and division of these by λ and



For 0·06 square inch, 11kV, and 0·06 square inch, 660V, single-core cables in air.

Fig. 3—Transient temperatures at equally spaced points in cable dielectrics

addition of 40 deg. Cent. would give directly the transient temperatures at equally spaced points in the dielectric of each cable, from the core to the sheath.

In the present case it has been found practical to obtain the transient voltages at the points 1, 2, 3, 4 and 5 for each network directly by standard Laplace or Heaviside methods. The consequent transient temperature curves at equally spaced points in the dielectric from core to sheath for 0·06 square inch, 11kV and 660V single-core cables in air are given in Fig. 3 for a duration of twenty seconds. It should be noted that no further analysis is required to obtain the transient temperatures at the points 1, 2, 3, 4 and 5 when the initial temperatures of the core and sheath assume any arbitrary values, as the required curves are obtained directly by an appropriate change of the ordinate in Fig. 3.

Table I—*Cable Constants.*

	11kV	660V	Units	Symbol in text
Radius of core	0·411	0·411	Cm	a
Inner radius of sheath	0·787	0·546	Cm	b
Thermal capacity per centimetre length of core	1·38	1·38	Watt sec/°C. cm	C_c
Thermal capacity per centimetre length of sheath	1·22	1·05	Watt sec/°C. cm	C_s
Thermal conductivity of insulant	0·00182	0·00133	Watts/cm °C.	k
Thermal diffusivity of insulant	0·00109	0·000795	Cm²/sec	D

Acknowledgment

The author wishes to express his thanks to Mr. L. Gosland, of the Electrical Research Association, for suggesting the present problem and for useful discussion with regard to it, and to the Director of the Electrical Research Association for permission to publish this article, which is based on the E.R.A. report, Ref. F/T179.

References

[1] Whitehead, S.: *Proc. Phys. Soc.*, 56, page 357 (1944).
[2] Jackson, R., Sarjant, R. J., Wagstaff, J. B., Eyres, N. R., Hartree, D. R., and Ingham, J.: *Journal of the Iron and Steel Institute*, No. 2, page 211 (1944); (2A), page 256; (2B), page 255; (2C), page 218.
[3] Same authors as in reference [2] above. *Phil. Trans., Royal Soc.*, Series A, No. 813, 240, page 1 (1946).
[4] Paschkis, V., and Baker, H. D.: *Trans. A.S.M.E.*, 64, page 105 (1942).
[5] British Standard Specification, B.S. 480 : 1942.
[6] Hutchings, E. E., Parr, R. G., and Gosland, L.: Technical Report Ref. F/T177. Electrical Research Association (to be published).

Sifting a Report

By Professor W. A. TUPLIN, D.Sc., M.I.Mech.E.

The gist of a report on a piece of research is best conveyed by numerical comparisons between the results and previous standards. Exceptionally good or exceptionally bad results should not be accepted unless some reasonable explanation can be found for them. Qualitative comment may be unconsciously biased and therefore misleading.

THE amount of experimental work that may have to be done to establish even one simple fact is often very great, and in that case the report on it tends to be voluminous. It is desirable to describe all that was done and how it was done, so that even the most critical reader need ask no questions and it may also be politic to do so in order to justify the time taken in completing the work. It is generally advisable to preface the report with a summary containing the result of the research in a nutshell if that is possible at all, particularly as the persons whom the report must particularly impress usually demand nutshell presentation because they expect the sifting of detail to have been completed by someone else. If, however, that has not been done, it is quite likely that the gist of the report will be missed by any reader who is not already well versed in the subject and actuated by a desire to find the truth however well concealed it may be.

The mass of information contained in Mr. O.S. Nock's article* "Performance and Efficiency Tests on the 'Britannia' Locomotives," and even more so in the bulletin of which it is an abstract, is a case in point. The figures given are the result of a very large amount of careful work and are necessarily voluminous; can their import be compressed into a few words? In finding an answer to such a question as this, it is essential, first of all, not to be abashed by the masses of material. Humility may be the right approach to the works of Nature, but not to those of man. A reader in reverent awe of an impressive report is as unlikely to unearth the precise truth as is an engine driver to get the best out of a locomotive of which he is afraid. A conviction that the roots of the matter are simple is a great help in drawing them cleanly out of clogging non-essentials and then their ability to withstand the light of reason may be rigorously tested without distraction.

A very long and detailed investigation into the performance of a locomotive may subconsciously suggest that the locomotive is exceptional in some way and this must first be considered. In actual fact, by comparison with British locomotives that have been running for twenty years or more, the "Britannia" is not exceptional in size or proportions. Any suggestion that its performance is exceptional in any way therefore demands examination. It is true that in the past, different designs of locomotive have shown such variations in quality of performance that some observers have come to believe that prediction of performance is impossible. They imagine design to be beset by some malicious demon that can be exorcised only by a quality of wizardry in the designer. They cherish hopes that as so many engines in the past have disappointed their designers, the balance may yet be redressed by a good fairy who will enable occasional designs to overleap natural laws. Optimism of this kind is a charming outcome of the emotional regard in which the steam locomotive is held, but it does not make for rational examination of a technical report.

Those who believe that there is scope for wizardry in locomotive design may find temporary confirmation for that idea in (for example) the fact that readjustments made at Swindon to the front end of a London Midland class "4" 2-6-0 increased the evaporative capacity of the boiler by what is described as a spectacular amount of "no less than" 89 per cent. The magic suggested by this presentation of the matter is somewhat dissipated when it is realised that the improvement merely brought the performance of the locomotive into line with that of other well-established standard types. What one would like to ask (in case the natural assumption should be incorrect) is by how much the redesigned front end differs from the Goss recommendations of 1908? They were sedulously disregarded by designers of some undistinguished locomotives in the past and very successfully adopted by others, and it would be valuable to know whether anything much better has since been discovered.

The bulletin relating to the tests on the "Britannias" mentions some operational features of the "large boiler fitted to these locomotives," but surely the boiler *is* the locomotive? Fitting a large boiler to a locomotive makes it a large locomotive, subject to the same proportional reduction in capacity by clinkering coal as is a small locomotive, and the larger reservoir of energy afforded by the large boiler is only proportional to its sustained power capacity. If a "Britannia" is given a duty within the normal capacity of a locomotive half its

* The Engineer, July 24 and 31, 1953.

size it can naturally still perform it even with a fire in very bad condition. This virtue does not arise from any feature in design or proportioning of the "Britannia," but simply from its size in relation to the work to be done, and it has to be set against the losses inevitable in using a locomotive that is larger than it need be.

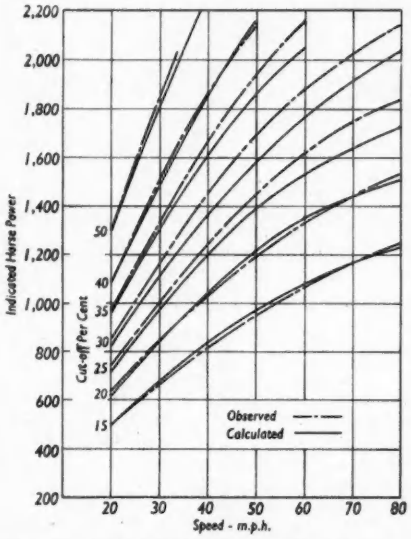
The curves for boiler efficiency against combustion rate for two different coals need examining rather critically. The obvious implication is that the difference in efficiency is associated with the difference between the calorific values of the coals and a little reflection on this point suggests the amendment of plotting boiler efficiency against the product of coal rate and calorific value. This, however, increases the difference between the curves corresponding to the two coals and suggests that the difference in efficiency has no essential connection with difference in calorific value. Does the quoted coal rate refer to the fuel delivered by the fireman or to the amount actually burned? Does "fired" mean "ignited" or only "handled by the fireman"? Does the coal of low calorific value have physical properties that lead to undue loss by discharge of unburned particles through the chimney? Boiler efficiency depends on the proportion of excess air; was this measured? These are perhaps questions for a fuel technologist rather than for an engineer, but the answers are of interest to both.

In comparing the coal consumption figures for these tests with those recorded on the road in the past (as, for example, during the 1948 locomotive exchanges) account must be taken of the fact that in the former case the coal was carefully broken to a suitable size for firing and everything smaller than 1in cube was screened out and not used. Such rejected coal might amount to 10 per cent of the original weight; in normal operating conditions it would be placed on the tender and eventually recorded as "consumed," whereas most of it would probably be lifted from the grate and discharged into the smokebox almost unburned in a locomotive being worked at the rate attained in the "all-out" test. This, together with the advantage of power output carefully controlled to near constancy, might give these test conditions an advantage of 10 to 15 per cent over normal running conditions. After applying this correction, the coal consumption of a "Britannia" when hauling about 500 tons at 60 m.p.h. on the level in normal operating conditions may be estimated from the charts in the bulletin to be about 3 lb per drawbar horsepower-hour, which is the figure to which many locomotives have approximated in service.

In Fig. 4 (*loc cit*) the curves relating indicated horsepower, speed and cut-off are what might be expected. To show this they are reproduced below (Fig. 1) and superimposed on them are the corresponding curves calculated from the generalised diagram reproduced as Fig. 2 in an article on "Locomotive Cylinder Power" in THE ENGINEER for February 10 and 17, 1950. The correspondence between the curves is close in most places and the greatest difference in indicated horsepower for any speed and cut-off does not exceed about 6 per cent. Even this discrepancy (probably within the limit of experimental error) might be explained by overtravel of the valves at high speed and cut-off, if the actual cut-off were not specifically measured at each and every speed run with each setting of the reversing gear. So these experimental curves are highly satisfactory in one way demanded by the late Sir Arthur Eddington, who was always reluctant to believe practical results unless he could find some explanation for them on the basis of existing knowledge. It is perhaps unfortunate that Mr. Nock referred (page 137) to "fine indicated horsepower characteristics," as "fine" may suggest something exceptional, whereas the cylinder performance certainly is not.

This illustrates the undesirability of making adjectival comment on a numerical subject. It cannot mislead the determined seeker for truth, but it may colour a report for a less exacting reader. It is sometimes deliberately done with that end in view, but the practice is not to be commended either for its ethics or for its reliability as the non-technical reader may enlist expert help to seek it out.

As the calculated curves in Fig. 1 are derived from calculated indicator diagrams, it is fair to say that the general form of the indicator diagram for any combination of speed and cut-off can be calculated. It may be presented on the base either of a reciprocating stroke of the piston or of continuous rotation of the crank, whichever may be preferred; either is easily and quickly convertible to the other. Calculated diagrams refer, of course, to valves and cylinders in perfect condition; the irregularities in the diagrams in Fig. 3 on page 104 (*loc cit*) are probably due to mechanical imperfections and could not be predicted by any general method.



Observed and calculated I.H.P. for "Britannia" class locomotives at various cut-offs

The remark on page 104 that a cut-off of 35 per cent may be regarded as "thrashing" needs treating with great caution. Any boiler will feed any cylinders at 35 per cent cut-off if the speed is low enough or if the steam is sufficiently throttled. For given cylinders and speed, 35 per cent cut-off may or may not overtax the boiler according to its size. The term "thrashing" seems hard to define in any strict numerical sense, but it is certain that whilst on any particular engine 35 per cent cut-off might constitute thrashing if the speed is high, it need not do so if the speed is low. The suggestion that some enginemen have in their minds cut-off figures that they imagine should not be exceeded is only too unhappily true. Some drivers have developed a habit of using a particular reversing gear setting for each part of the road regardless of boiler pressure or possible errors in the cut-off indicator and then blame the engine if it loses time because of adverse conditions which the driver has not attempted to counter. Similarly, a driver may refrain from "opening out" a locomotive where it might be done with advantage simply because, never having tried it, he believes it might run the engine out of breath as, indeed, it would if the fireman did not co-operate in such enterprise. On the other hand, keen and intelligent crews unrestrained by imaginary limitations have spurred locomotives of many classes to maximum efforts comparable in intensity with those of the "all-out" test run of the "Britannia."

There is nothing necessarily devastating or inefficient about a cut-off of 35 per cent and whether an engine can "take it" or not depends on the relation between the indicated horsepower and the size of the boiler. An output of 2200 i.h.p. is not exceptional for a locomotive with a grate area of 42 square feet as the rate of 52·5 i.h.p. per square foot of grate area has been attained by a wide variety of British locomotives in the past and has been surpassed by about 40 per cent in sustained running by certain locomotives in France. In one such case at least coal was handled by one man at the rate of about 110 lb per minute, for nearly three hours, and this, compared with the decision that two men were required to fire a "Britannia" at 85 lb per minute, may surprise those who do not normally associate Frenchmen with physique.

This must not be taken as a suggestion that British firemen are incapable of such diligence, for there is at least one recorded effort by a Gresley "A4 Pacific," to which the fireman was probably feeding coal at a higher rate than the two firemen achieved between them on the high-power test of the "Britannia" on the Carlisle–Settle route. Furthermore, the 1939 test run of L.M.S. "Duchess," No. 6234, with dynamometer car between Crewe and Glasgow showed drawbar horsepowers comparable with those recorded behind No. 70005 on the "all-out" run even though the 1939 trips were longer and only one fireman rode on the footplate at any one time. So far as power output in relation to size is concerned (e.g. drawbar horsepower/grate area) the maximum effort of the "Britannia" on test has been surpassed by various British locomotives, as may be seen from an article in THE ENGINEER, October 17, 1952, page 506. So No. 70005 broke neither a record nor herself during the "all-out" test, although her performance was comparable with previous bests.

The similarity between the figures on page 103 (*loc cit*) relating to power output per square foot of grate and to coal per indicated horsepower hour is not really surprising. For at least twenty years, design of British locomotives has been tending towards the rational basis demonstrated at Swindon nearly fifty years ago and uniformity has now been closely approached. So there is nothing remarkable about consistency of performance between a Western Region locomotive of old design and three others designed and built elsewhere in the last three years unless, indeed, it is held that some works are significantly less skilful than others in locomotive construction. The L.M. class "4" 2–6–0, the B.R. class "4" 4–6–0, the W.R. "Hall" and the "Britannia" with indicated horsepower per square foot of grate lying between 50 and 53·5, show consumptions of Blidworth coal between 2·3 lb and 2·5 lb per indicated horsepower-hour. What is extremely surprising (if it is true) is the figure of 1·8 lb per indicated horsepower-hour implied in an earlier bulletin relating to a Thompson "B1" 4–6–0 and recorded in THE ENGINEER for July 4, 1952, page 30. The figure quoted is 2·48 lb of Blidworth coal per drawbar horsepower at 60 m.p.h. The drawbar horsepower was 1000 and the corresponding indicated horsepower was probably about 1400, in which case the coal rate per indicated horsepower was $2{\cdot}48 \times 1000/1400 = 1{\cdot}8$.

As there is far less difference between a "B1" and a B.R. class "4" 4–6–0 than between that engine and a "Britannia," the figure of 1·8 lb per indicated horsepower cannot be accepted without some explanation. A transcription error is far more likely than a 22 per cent difference in efficiency between locomotives with no constructional difference that could explain such superiority over the norm. It is interesting to note that the figure of 2·48 lb quoted per drawbar horsepower is about right for indicated horsepower lying, in fact, within the range for the other four classes of locomotive.

Other figures that seem most unlikely to be correct are those quoted for the difference between indicated horsepower and drawbar horsepower of a "Britannia" at speeds from 50 to 70 m.p.h. It is remarked (page 137) that power losses in locomotives rise sharply with speed, the obvious reason being that air resistance and inertia forces in the motion are roughly proportional to the square of the speed. The fact that figures given for the "Britannia" do not show the same trend as for other locomotives should not be taken as an indication of some special virtue in the "Britannia" (which has no unconventional major feature), but of probable error in the figures. They were derived from small-scale curves in the bulletin, and were not claimed to be accurate.

The fact is that certain innocent-seeming arithmetical processes may be quite illegitimate when applied to points on different curves representing experimental results. The neat precision of a printed curve in a finished report may cause the reader to forget that it is merely a reasonably guessed mean of a series of points plotted with the unavoidable uncertainty of experimental error. Now the curves for indicated horsepower and drawbar horsepower are derived from two entirely different sets of measurements and are therefore affected by two entirely independent families of experimental errors. A power-loss figure determined by difference between indicated horsepower and drawbar horsepower is affected by two sets of experimental errors, two plotting errors and two reading errors. If the result appears reasonable in the light of other information on locomotive resistance, it is probable that the errors have tended to cancel each other ; if the result appears unreasonable it is almost certainly incorrect.

Figures for power losses in locomotives of different classes (or even in different locomotives in the same class) are not distinguished for consistency and so no formula for those losses can be more than approximate. So far as British locomotives at least are concerned the power loss at speeds over about 40 m.p.h. may be estimated by the Johansen formula for British coaching stock. For an engine and tender the power loss approximates to the Johansen figure for coaches of equal total weight at the speed concerned plus that for a load equal to 1·5 times the adhesion weight of the locomotive at a speed equal to the actual speed multiplied by 3×(piston stroke)/(driving wheel diameter). Applied to a "Britannia" this formula gives power losses of 350, 490 and 685 h.p. at 50, 60 and 70 m.p.h. respectively as against the uncertainly derived ones of 390, 470 and 575 quoted on page 137. As these last figures correspond to a resistance that rises only 7 per cent between 50 and 70 m.p.h. and as the highest one is about the same as that given in THE ENGINEER, July 11, 1952, page 63, for the much smaller "Hall" class 4–6–0 at 65 m.p.h., the 575 h.p. for 70 m.p.h. is too improbable to be accepted.

Summarising, it may be fairly said that the "Britannia" performs in accordance with the standards that past British practice would lead one to expect. Coal consumption when working fairly hard in normal service is about 3 lb per drawbar horsepower-hour and about 2·2 lb per indicated horsepower-hour. Drawbar horsepower per square foot of grate area can be about 40 for thirty minutes or 50 for shorter periods. All these are figures that have been achieved by older classes.

On power development and efficiency the "Britannia" is satisfactory by previous standards and that is probably as much as can be expected in a locomotive of conventional design. Over earlier British locomotives of comparable power the "Britannia" has a distinct advantage in simpler construction, lower prime cost and (probably) lower maintenance cost, but not in performance.

As so often happens in research work, this report raises questions as difficult as any that it answers, and to the usual pious exclamation of "Long may it be so!" one can confidently rejoinder "Never fear!"

Gantry-Mounted Linear Accelerator for X-Ray Therapy

A gantry-mounted linear accelerator for X-ray therapy is in operation at the General Hospital, Newcastle upon Tyne. This installation has an energy rating of 3·5 to 4MeV. The gantry can be rotated through 225 deg. and the couch can be adjusted for height and orientation, so that the beam can be directed on to the patient in the required place and at the required angle. A brief description of the equipment is given here.

FIVE gantry-mounted linear accelerators are being made by Mullard, Ltd., on behalf of the Ministry of Health for installation in radio therapy centres in this country. The first of these accelerators is now in service at the General Hospital, Newcastle upon Tyne. The remaining four machines will eventually be installed at the Christie Hospital, Manchester, the Radium Institute, Liverpool, the Mount Vernon Hospital, Northwood, and the Royal Infirmary, Edinburgh.

The linear accelerator at Newcastle was developed and built by the Mullard Research Laboratories, Redhill, Surrey, on behalf of Philips Electrical, Ltd. Installation was carried out during the summer and autumn of 1953. Treatments were first made in December, 1953, and treatment on a routine basis began in January, 1954. The new machine is intended for research as well as for routine treatments.

The design of this accelerator represents a compromise between the demand for X-rays of higher energy and intensity and the need for a practical working machine of comparatively simple construction that could be put into immediate use in a busy radiotherapy department. By taking advantage of recent improvements in the design of wave-guide systems (Fig. 3) it was possible to reduce the length of the accelerator to such a point that it could be conveniently mounted in a movable gantry.

The choice of the operating conditions of 3·5 to 4MeV for the Newcastle installation was also governed by the fact that the characteristics of the X-rays within its energy range were sufficiently akin to the known characteristics of the 1MeV and 2MeV X-rays that have already been used, as to enable the machine to be used immedately on the basis of existing knowledge.

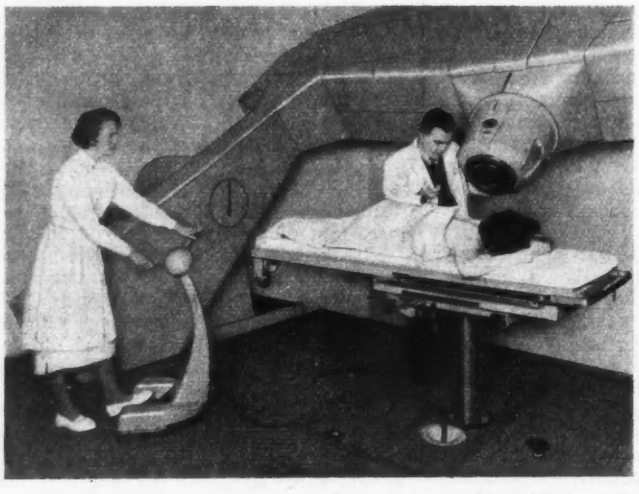


Fig. 1—Positioning the patient for treatment. For all positions of the gantry the X-ray beam cuts the axis of the couch at the same point

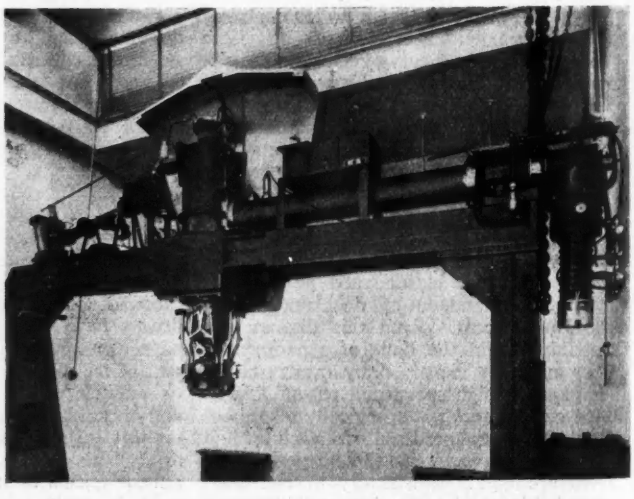


Fig. 2—Linear accelerator with covers removed to show the X-ray head (centre), the magnetron and rat-race (left) and vacuum pump (right)

The principle of operation of the Mullard linear accelerator is basically as follows. A magnetron (Fig. 3) produces a succession of high-energy bursts of short radio waves as in a high-power radar transmitter. These waves are used to accelerate a beam of electrons down a specially designed copper tube. This tube is iris-loaded to form a corrugated wave guide so that the electrons are caused to travel with the waves and extract energy from them. The electrons enter the wave guide—which for the 4MeV machine is 1m (39in) long—at low velocity, and they leave it with a velocity of 99·3 per cent of that of light. As a result of the considerable dependence of mass on velocity at such high velocities, the electrons are then eight times heavier than they were at entry. When these very fast electrons are stopped suddenly by a heavy metal target they produce very hard X-rays, i.e. short-wave X-rays.

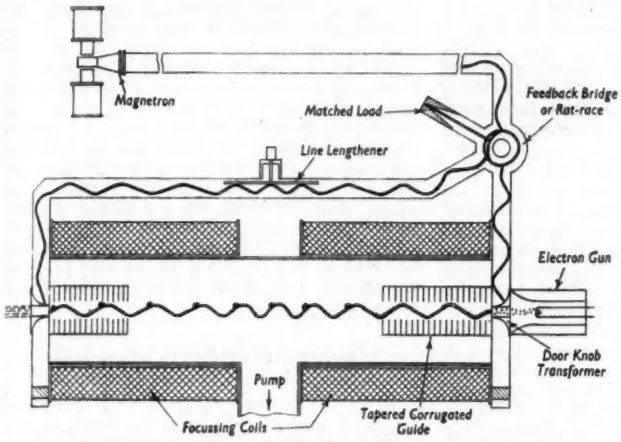


Fig. 3—Diagram showing the principle of "feed back," in which the unused r.f. energy at the target end is recirculated and added to the incoming power

The Newcastle linear accelerator operates at a pulse repetition frequency of 400 p.p.s. and a mean beam current of 150μA. Under these conditions the X-ray output is approximately 250r/min. at a distance of 1m without filtration. Higher outputs are possible for shorter periods, the limitation on the amount of increase and duration being governed principally by the magnetron. The overall energy consumption from the mains is of the order of 15kW.

The gantry mounting of the linear accelerator (Figs. 2 and 3) means that the X-ray beam can, in practice, be directed on to the diseased tissue with precision and at any required angle while the patient lies on the treatment couch. The gantry can be rotated through a total angle of 225 deg., i.e. from 30 deg. below the horizontal on one side to 15 deg. below the horizontal on the other side.

The gantry which houses the linear accelerator is driven by an oil motor through a reduction gear, the pressure oil being provided by an electrically driven pump. Close, variable-speed control of this drive can be maintained from the control pedestal which can be seen in Fig. 1.

Besides being adjustable for height, the couch is designed to give adjustment in the horizontal plane so that any part of the patient can be brought in line with the X-ray beam. The arrangement is such that, in all positions of the gantry the beam will always cut the axis of couch at the same point. A patient lying on the couch can thus be brought quickly to the correct position for treatment and only simple adjustments to the couch height and horizontal position are required. Adjustments of the couch are effected from the control pedestal (Fig. 1), which is mounted on castors so that it can be moved to suit the operator. The couch top can, if required, be replaced by a treatment chair.

The time taken for setting up the patient in the treatment room is said to be about five minutes and the treatment times are about two minutes per field.

An optical system consisting of a light and mirror is arranged so as to illuminate the exact treatment area on the patient's skin. An additional optical system, recently fitted by the physicist and technical staff on site, operates as a range-finder giving an accurate indication of 1m distance from the target. A mechanical back-and-front pointer system is also provided. During setting up and actual treatment no physical contact is made between the X-ray head and the patient, i.e. no applicator is required. The X-ray head (Fig. 4) is, in fact, always at least 1ft (30cm) away.

Briefly the treatment procedure is as follows. The diseased part of the body is first precisely located by radiographic and other means. The treatment is then planned, using the physical data relating to the radiation in such a way that exactly the required dose is given to the diseased region. The radiotherapist in charge of the machine treats the patient in accordance with a treatment schedule which he has worked out in collaboration with the physicist. The radiographer, who operates the controls, can view the patient during treatment by means of a periscope fitted to the control desk. Two-way communication with the patient is provided by microphones and loudspeakers.

The Control Equipment.—The control desk for the radiographer incorporates all the controls and instruments necessary for the treatment of patients. Dose-rate meters, a dose meter and dose-setting controls, together with a timer, are built in. In general, the operator's control is simple and differs little from that of a conventional therapy machine.

In the apparatus room there is a separate control desk specially designed to enable the physicist to take measurements and check the general performance of the machine. Also located in this room are the modulator, a rack unit carrying the power supplies and various control and interlocking circuits, and a backing pump which connects to a diffusion pump on the gantry which, in turn, is connected to the accelerator through a large rotating vacuum joint. A vacuum measuring trolley is also kept in the room for checking pressures in the accelerator. This comprises a Penning, an ionisation and a Pirani gauge.

The Megavoltage Treatment Building in which the linear accelerator is installed was presented by the North of England Council of the British Empire Cancer Campaign. It was specially designed to accommodate this linear accelerator and other equipment of the "super-voltage" class, such as telecurie machines using cobalt 60 or caesium 137 as the radiation source.

Complete protection of the staff against stray radiation is given, for example, by the wall of the treatment room facing the direction of the primary X-ray beam, which is of concrete, 5ft thick. The remaining walls are 3ft thick. The complications associated with heavy protective doors have been obviated in the layout of the building by a "kinked" design of corridor between the control and treatment rooms to serve as a trap for scattered radiation.

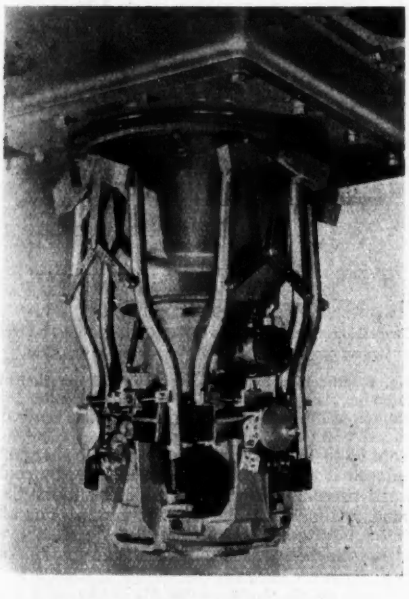


Fig. 4—X-ray head with cover removed

History of Gas Manufacture and Distribution

A NEW gallery devoted to the history of gas manufacture, its distribution and its by-products up to the present day, was opened at the Science Museum on Tuesday, May 25th. This represents the first collective effort by an industry on behalf of the permanent collections at the Science Museum. The display occupies a gallery of some 5000 square feet in a newly finished wing of the Museum and has been organised by a committee of the Institution of Gas Engineers upon which the Gas Council, various manufacturing interests and the Science Museum are represented.

The gallery is arranged to illustrate not only the beginnings of the making of gas, first, for lighting and then for heating, and its industrial uses, but also the later uses of the many by-products of coal created through the gas-making process.

A series of realistic dioramas shows some of the early experimenters at work, followed by representative retort houses at various dates up to the present day. A cyclorama running the whole length of the gallery depicts London's gas-lighted streets in 1812, the gas-lit scene at a Mansion House ball as long ago as 1830, private house lighting thirty years ago, and the advent of the incandescent mantle sixty-four years ago. Models representing gas works in 1890 and 1950 show the progress of the machinery for gas-making.

Illuminated panels, operated by push buttons, show by animated diagrams the various stages in the extraction of gas from coal, how it is distributed to the consumer, and what happens to the by-products that remain.

Royal Aeronautical Society Awards

ON the occasion of the forty-second Wilbur Wright Memorial Lecture on Tuesday, May 20th, read before the Royal Aeronautical Society, certain of the Society's medals were awarded by the president, Sir Sidney Camm. Honorary Fellowship Diplomas were awarded to Sir A. H. Roy Fedden, and Sir Frank Whittle. Sir Geoffrey Taylor received the Gold Medal for his outstanding contributions to aeronautical science, and the Silver Medal was awarded to Professor W. J. Duncan for his work in aeronautical science and education. The Society's Bronze Medal was presented to Mr. H. B. Howard for his work on aircraft structures. For his practical achievement on the design and development of aircraft engines, Mr. A. G. Elliot was awarded the British Gold Medal, and the British Silver Medal was awarded to Mr. R. Brie for his practical contributions to the development of rotary wing aircraft. Gold Medals for the most valuable contribution published by the Society were awarded to Mr. V. A. M. Hunt and Mr. E. D. Keen.

Book of Reference

Water Engineer's Handbook, 1954. The Colliery Guardian Company, Ltd., 30 and 31, Furnival Street, Holborn, London, E.C.4. Price 18s.—The 1954 edition of this reference book embodies the same categories of information as previous editions. The largest section is a directory of water undertakings in the British Isles. Information related to water engineering, both technical and administrative, is also included.

Metallurgical Topics

Seizing of Metals

THE mechanical aspects of seizing in metal wear have been discussed in a qualitative manner by H. Czyzewski* in a paper to the American Society of Mechanical Engineers. He distinguishes between normal mechanical abrasion (as produced, for example, by emery paper) and accelerated mechanical abrasion in which the track left by the abrader has a larger profile than that of the contacting part of the abrader. Seizing is defined as the state in which the relative motion of the opposing metal parts is stopped, because the track increases in profile until further propagation of the track requires more translational energy than is available. Galling may be defined as arrested seizing, occurring

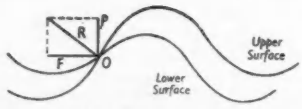


Fig. 1—Diagram illustrating forces due to asperities of the upper surface acting on asperities of the lower surface when the normal pressure *P* is comparatively low

when the increased track profile becomes constant or decreases with continued propagation of the track. In metal-to-metal wear the metal parts are in relative motion. The high spots on the contacting surfaces do not make point contacts, but contacts over a certain area. The effect of the translational component of force is to increase the shear stress laterally in the region of contact. Plastic deformation occurs to an extent depending on the work-hardening properties of the material.

Normal mechanical wear can be represented by a diagram such as that shown in Fig. 1, in which high spots of the opposing surfaces make contact. The effect of the upper asperity on the lower asperity at the point of contact *O* is indicated by the two components, a normal force *P* and a translational force *F*. In this case *P* is relatively low and the resultant *R* acts at a small angle to the surface. The net result is that the metal of the lower surface will tend to flow round the upper asperity. In the ideal case of normal mechanical abrasion the upper asperity must be completely rigid. Accelerated mechanical abrasion is illustrated in Fig. 2. The normal force *P'* is much greater than *P*, and *R'* is greater than *R* and acts at a larger angle to the surface. There is a tendency for the lower asperity to flow upwards in front of the upper asperity. This effect, repeated at innumerable high spots, causes *P'* to increase and *R'* to become nearly normal to the surface. This is a case of increasing instability: the increasing reaction of the lower asperity causes an increase in the incident force. The volume

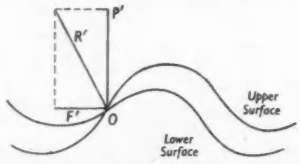


Fig. 2—Diagram illustrating forces due to asperities of the upper surface acting on asperities of the lower surface when the normal pressure *P'* is comparatively high

of the metal of the lower surface that is plastically deformed increases until the translational component of the incident force is insufficient to overcome its resistance, the relative translation of the two opposing surfaces stops and seizing occurs.

The author proceeds to show that this method of regarding mechanical wear is consistent with well-known observations of the behaviour of metals in contact.

Effect of Normal Pressure.—It is well established that galling and seizing are increased by an increase in normal pressure between the opposing surfaces. Lubricants are generally considered to alleviate the tendency to seize by separating the opposing metal surfaces so that high local concentrations of load are not incurred.

Effect of Surface Finish.—Lubrication theory predicted that the separation of the opposing metal surfaces would be accomplished more easily if the surface finish were improved, i.e. if all the asperities were removed. It is known, however, that a high order of surface finish increases the tendency for galling and seizing. In explanation of this, the author puts forward Fig. 3, which indicates that a low-order surface roughness tends to gall because the amount of deformation (*a*) that will cause instability is so much reduced. It was pointed out in the discussion that this explanation should be restricted to dry lubrication conditions. Smooth surfaces make more easily possible the formation of a fluid film which will separate the moving surfaces completely; but, if the film is ruptured and contact occurs, galling and seizing take place more readily with smooth surfaces than with rough surfaces.

Effect of Temperature.—The tendency to gall increases with rise in temperature. This is consistent with decrease in critical shearing stress as temperature rises.

Effect of Velocity.—Increase in velocity is generally credited with an increased tendency to gall. This may be accounted for by an increase in temperature of the rubbing surfaces.

Effect of Foreign Particles.—Foreign particles in close fitting parts produce high localised loads which start the seizing reaction.

SELF-LUBRICATING ALLOYS

For the purpose of reducing the tendency to galling, the most widely adopted attribute of the metal structure is self-lubrication. Self-lubrication is exemplified by porous metal

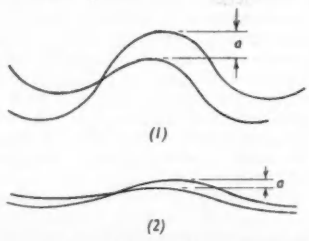


Fig. 3—Diagram illustrating the effect of surface smoothness: (1) comparatively rough surfaces in contact, and (2) comparatively smooth surfaces in contact

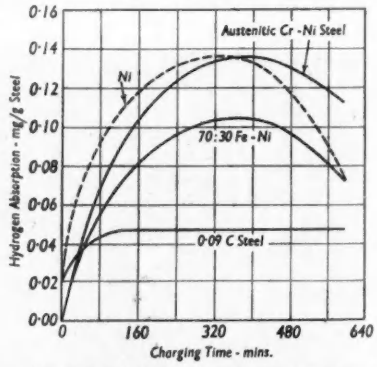
products (impregnated with oil), grey cast iron and graphitic steels (graphite lubricated) and the lead bronzes (lead lubricated). Mechanical aspects of seizing provide reasons for the success of such alloys. For example, if the lower surface shown in Fig. 2 were that of a powder-metal product, cavities or soft spots would be present at such sites as below or to the right of the point of contact. If the cavity lies below the point of contact, the load *P'* will not be resisted as rigidly, the point *O* will drop and part of the load *P'* will be distributed over the neighbouring region, so seizing will not be initiated. If a cavity is to the right of *O*, the asperity will be less able to resist the translational force *F'* and will have to move laterally and not upwards. Seizing, if begun, would therefore be terminated rapidly. Both facts—that self-lubricating alloys have a greater resistance to seizing and suffer less damage by galling—are accounted for. On this basis porous alloys without lubricant may be expected to gall less than non-porous alloys also unlubricated. The importance of graphite flake size, shape and distribution in grey cast iron is well known. In practice the graphite flake classification is controlled closely for such parts as piston rings, cylinders, &c. It has been stated that for equal graphite contents and similar matrix structures, the resistance to galling of flake-graphite iron is superior to that of ductile iron. The ductile (nodular graphite) cast iron was equal in resistance to galling to a grey iron of lower flake graphite content. Chemically pitted surfaces are known to be superior to super-finished surfaces in wearing characteristics. Porous chromium-plated surfaces are better than non-porous surfaces in resistance to galling and channel porosity in chromium plate is superior to the rounded pit type of porosity.

In most industrial applications the mechanical effects, with which the paper deals, are complementary to the lubricating-film effect of separating the surfaces, but somewhat decrease the importance of the lubricating-film effect alone. There is, in the opinion of the author of the paper, ample evidence that empirical methods have in many cases determined the importance of micro-scale "engineered roughness," the value of which is predicted qualitatively from the mechanical analysis of accelerated mechanical abrasion.

* *Trans. A.S.M.E.*, April, 1954, page 381.

Absorption of Hydrogen by Austenitic Steels during Cathodic Treatment

IN an investigation reported by F. Eisenkolb and G. Ehrlich,* three austenitic steels (carbon 0·05 to 0·17, chromium 16·0 to 17·4, and nickel 7·7 to 8·5 per cent), a 70 : 30 iron-nickel alloy, metallic nickel and an unalloyed 0·09 per cent carbon steel were cathodically charged with hydrogen; and the influence of different electrolytes, of small additions of arsenic, lead, sulphur or selenium to the electrolyte, of the conditions of electrolysis, and of prior treatment of the steels were studied. Hydrogen absorption was measured and the resulting embrittlement determined by subjecting specimens of the 0·2mm thick sheet employed to reversed bending tests. The results showed that on cathodic charging an absorption of hydrogen occurred, but an essential difference in behaviour of austenitic steels compared with ferritic steels was that the amount of hydrogen absorbed passes through a maximum and then diminishes as the charging is continued (Fig. 1). The accompanying brittleness showed a similar change. The number of reversed bends withstood without fracture by the austenitic steel referred to in Fig. 1 was 35, falling to 28 after cathodic charging for 360 minutes and then rising to 30 after 600 minutes. By heating the steel at 750 deg. Cent. the bend test figure was reduced



Composition of the Cr-Ni steel: C 0·17, Cr. 16·5, Ni 7·7 per cent
Current density 0·1A/sq cm. Temperature 35 deg. Cent.

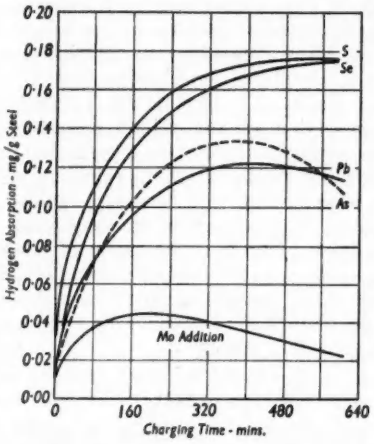
Fig. 1—Effect on hydrogen absorption of duration of cathodic charging in 2N sulphuric acid with the addition of 250 mg/l of arsenic (Eisenkolb and Ehrlich)

from 35 to 16, and subsequent cathodic charging reduced it still further to 8. Similarly, by cold work exceeding 20 per cent deformation, the bend test fell from 35 to 12 reversals. For all amounts of cold work up to 20 per cent, above which magnetic tests showed the formation of

* *Archiv für das Eisenhüttenwesen*, March/April, 1954, page 187.

increasing amounts of the α-solid solution, the results of the bend test remained constant at 35, and were reduced by cathodic action to 28, the same figure as shown by the unworked material. When the amount of cold work was increased beyond 20 per cent the bend test figure fell gradually to 12 (at 54 per cent cold work) with a further fall after cathodic charging to 2. The results of bend test on the other materials in Fig. 1 were :—30 per cent nickel-iron, 37 falling steadily to 20 after 600 minutes' charging ; mild steel, 33 falling rapidly to 15 after 30 minutes, then remaining constant ; and nickel, falling even more rapidly from 36 to 5 in 30 minutes, to 2 in 60 minutes and then remaining constant at 1.

The maximum amount of hydrogen absorbed was greater with hydrochloric acid as electrolyte than with sulphuric acid ; it was increased slightly by raising the temperature of the electrolyte from 25 deg. to 35 deg. Cent. and considerably by raising it to 50 deg. Cent. Hydrogen absorption was greatest in the 0·05 per cent carbon austenitic steel and diminished with increase in carbon content, and it was greatly influenced by addition to the electrolyte of small quantities of the same elements as those which Körber and Ploum† found to have catalytic



Current density 0·1A/sq cm. Temperature 35 deg. Cent.

Fig. 2—Effect on hydrogen absorption by the austenitic steel in Fig. 1 of duration of cathodic charging in 2N sulphuric acid with different additions (Eisenkolb and Ehrlich)

properties in connection with hydrogen absorption by ferritic steels when they were treated in acids. Typical results are shown in Fig. 2. With additions of sulphur or selenium, the fall from a maximum either does not occur or was not reached in the time to which the experiment extended.

No marked permeability of the austenitic steel to hydrogen at room temperature was observed. By exposure to the atmosphere at room temperature for one day, the hydrogen content of an austenitic steel, cathodically charged with 0·11 mg per gramme of steel, fell to 0·033 mg per gramme, and thereafter remained constant. From the comparatively small degree of brittleness of the austenitic steels, and the rapid evolution of hydrogen that occurred without any residual damage, it was concluded that almost the total amount of the absorbed hydrogen was contained in a surface layer of the steel. In the bend test the maximum stress is in the outer layers ; and, to produce a decided effect, it is enough that the surface becomes enriched with hydrogen.

Hot Steel Extrusion

It is reported that extruded steel sections are now available on an experimental scale for aircraft parts in America.* Under a U.S. Air Force-Lockheed contract, Harvey Aluminium have been carrying out research and development work on hot steel extrusion, and by modifying their aluminium presses to work at higher speed and rebuilding containers to withstand higher temperatures they have succeeded in extruding 30ft lengths of nickel-chromium-molybdenum steel from 6in diameter billets at a temperature of 1260 deg. Cent. and a pressure of 67 tons per square inch. Early attempts failed to maintain dimensional tolerances. The outstanding difficulty was the effect of the high temperature on the die, and success has been largely due to the development of a superior die material. Details of this are not given, but it is implied that molten glass proved to be satisfactory as a lubricant. It is estimated that the use of extruded sections will result in a 66 per cent saving in cost of machined parts for the Lockheed "Constellation." In one example, the cross-sectional area of the extrusion, equal to that of the finished part, was 1·3 square inches, while the bar from which it was machined had a cross section of 3·5 square inches. This initial success may lead to further application of extruded steel sections in the aircraft and other industries.

† *Mitteilungen aus dem Kaiser-Wilhelm Institut für Eisenforschung*, 1932, Vol. 14, page 229.

* *Materials and Metals*, February, 1954, page 96.

Internal Stresses Due to Flame Hardening

The use of an oxy-acetylene or oxy-coal-gas flame is a convenient method of rapid local heating. Either the torch or the work itself can be moved at such a rate that the surface temperature of the steel is raised above the critical temperature. Cylindrical parts may be rotated before a stationary flame. A flat component may be immersed in shallow water which flows over the surface as the flame moves away, or an air jet or liquid spray may be made to follow the torch and quench harden the surface. The depth of flame hardening may be adjusted to suit requirements. A flame-hardened steel, like a carburised or a nitrided steel, presents a hard, wear-resisting surface over a tougher and more ductile core ; but as flame hardening does not involve any change in composition, the steel must be chosen to give the required hardness on quenching. Steels with 0·35 to 0·65 per cent of carbon are suitable. Steels of high carbon content do not provide sufficient ductility in the core and are more liable to surface cracking. The fully hardened condition, especially in the higher carbon steels, is accompanied by pronounced brittleness. Moreover, the formation of martensite takes place with an increase in volume compared with the pearlitic structure of the unhardened steel, and the steel being in a rigid condition at the time of the austenite to martensite transformation, stresses which may reach a high value are induced. The hardening operation must, therefore, always be followed by a tempering or stress-relieving treatment. This is intended to reduce internal stress and at the same time to remove some of the brittleness by slightly decreasing the surface hardness.

Measurements of the magnitude and distribution of internal stress in flame-hardened cylinders of steel have been made by Hans Bühler,* who also determined the effect of subsequent treatment in relieving the internal stress. With cylindrical specimens, 150mm long, of steel A (diameter 45mm) and B (diameter 58mm), he studied the effect of surface hardening by oxy-acetylene and oxy-coal-gas flames. The steels A and B contained carbon 0·31 and 0·50 per cent respectively, each with about 0·65 per cent of manganese. The round bars of both steels were surface hardened by the rotational process with automatic feed in an oxy-coal-gas flame, steel B in an oxy-acetylene flame also. An example of the results is given in Fig. 1, which shows the distribution of stress ascertained by turning off successive layers of the bar to a depth of about 10mm (initial cross section 26·4 square centimetres, final cross section about 11 square centimetres). The maximum internal stress in the core is 31kg per square millimetre longitudinal and 24kg per square millimetre circumferential tension, while the compression in the surface layer reaches about 90kg per square millimetre (57 tons per square inch) in both directions.

* *Archiv für das Eisenhüttenwesen*, March/April, 1954, page 153.

The influence of different rates of feed was investigated. As the rate of feed was increased, the depth of hardening diminished, thus :

Flame Hardened by Oxy-Coal-Gas Fame

Rate of feed, mm/min	Depth of hardened layer Carbon 0·31 per cent, mm	Carbon 0·50 per cent, mm
80	5·5	9·0
100	5·0	7·0
130	4·5	5·0
160	4·0	4·0
190	3·8	2·6
210	2·0	—

With an oxy-acetylene flame, the depth of hardening in the 0·5 per cent carbon steel decreased steadily from 9·5mm to 1·1mm as the rate of feed was increased from 70mm to

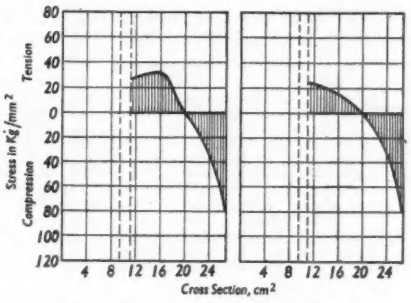


Fig. 1—Distribution of internal stress, calculated from change of dimensions on turning down a cylinder of steel B, 58mm diameter, after surface hardening with an oxygen-coal-gas flame and a feed of 130mm per minute (Buhler)

185mm per minute. The internal stresses were at a maximum when the rate of feed was 125mm per minute for oxy-acetylene and 160mm per minute for oxy-coal-gas, the corresponding depths of hardening being 4·2mm and 4·0mm respectively. It thus appeared that the depth of hardening, or possibly the ratio of the hardened area to the total area of cross section, determined the magnitude and distribution of the residual stress. This ratio was 0·324 for steel A and averaged 0·262 for steel B (0·256 with coal gas,

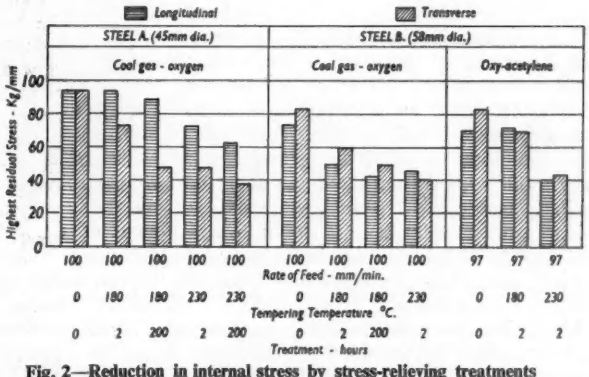


Fig. 2—Reduction in internal stress by stress-relieving treatments of flame-hardened specimens (Buhler)

and 0·268 with acetylene).

The influence of stress-relieving temperatures (180 deg. to 230 deg. Cent.) and also times of treatment (2 to 200 hours) on the reduction of internal stress was also studied. The order of magnitude of the residual internal stress due to surface hardening after different stress-relieving treatments is shown diagrammatically in Fig. 2. Very long stress-relieving times offer no advantage in comparison with a very slight increase in temperature. Such increase, however, is limited by the need to avoid undue softening of the surface layer. The reduction in internal stress is of the same order of magnitude as that produced by similar treatment applied to steels of the same carbon content in the water-hardened condition.

THE ENGINEER

Vol. 197 MAY 28, 1954 No. 5131

LEADING ARTICLES—
London's Traffic 786
Coal 786

ARTICLES—
Annual Road Research Report 769
Armature Winding Machine. (Illus.) 799
Automatic System for Mass Production of Electronic Devices. (Illus.) 790
Calculation of Transient Heating in Single-Core Cable Dielectric. (Illus.) 779
Compressed Air Filter. (Illus.) 800
Echo Sounding Recorder. (Illus.) 799
Extrusion of Stainless Steel Sections. (Illus.)... 797
Feed Attachment for Power Presses. (Illus.)... 798
Fixed Frequency 1kW Radio Transmitter ... 799
Flow Controller. (Illus.) 800
Forty-Second Wilbur Wright Lecture 769
French Locomotive Experiences. No. X. (Illus.) 773
Front Wheel Drive Bulk Loader. (Illus.) ... 799
Gantry-Mounted Linear Accelerator for X-ray Therapy. (Illus.)... 781
German Industries Fair, Hanover. No. III. (Illus.) 775
High-Density Tungsten Alloy. (Illus.) 795
High-Speed Automatic Gear Hobbing Machine. (Illus.) 796
History of Gas Manufacture and Distribution 783
International Railway Congress, 1954. No. I 789
Kelvin Medal Award to Dr. C. J. Mackenzie... 769
Light-Duty Hand-Operated Fork Truck. (Illus.) 800
Locomotive Manufacturers' Association of Great Britain... 769
M.I.R.A. Proving Ground. (Illus.)... 793
Royal Aeronautical Society Awards 783
Runway Expansion Joint Filler 772
Scottish Industries Exhibition 769
Sifting a Report. (Illus.) 780
Some Recent Swiss Hydro-Electric Schemes. No. VI. (Illus.) 771
World Production by A.D. 2000 769

METALLURGICAL TOPICS—
Seizing of Metals. (Illus.) 784
Absorption of Hydrogen by Austenitic Steels During Cathodic Treatment. (Illus.) ... 784
Hot Steel Extrusion 785
Internal Stresses Due to Flame Hardening. (Illus.) 785

LETTERS TO THE EDITOR 788

LITERATURE 787

OBITUARY—
F. M. G. Du-Plat-Taylor 787

NEWS AND NOTES—
Books of Reference 683
British Patent Specifications. (Illus.) 803
British Standards Institution 804
Contracts 802
Forthcoming Engagements... 804
Industrial and Labour Notes 801
Launches and Trial Trips 804
Notes and Memoranda 802
Personal and Business 802
Technical Reports 800
Steel-Making Processes 794
Work of the Bureau of Reclamation... 794

LONDON'S TRAFFIC

Often enough during the past few years we have drawn attention to the need on grounds of enhanced safety and economy of improving the existing roads of this country, building new roads, and ridding main arteries of the bottlenecks from which nearly every one suffers. The carrying out of that work is urgent enough. What is becoming at least equally urgent is the provision of relief for the rapidly growing traffic of London, not to speak of that of certain other large cities. Nor would the relief of London's traffic congestion, even at the very high cost necessarily involved, be uneconomic. Last year it was stated by Mr. Callaghan in the House of Commons that if the average speed of London's buses could be raised by so little as 1 mile per hour there would be a saving to London Transport of £2,000,000 a year. How much more would be saved if, for example, the lorry traffic to and from the docks could be similarly speeded up ? And how impossible it is to estimate what benefits would flow to businessmen and businesses if journeys by car in London took less time and space to park were easier to find !

Many have been the road improvement plans suggested for the relief of traffic congestion in London. Very few of them have been carried out. Partly, no doubt, the cost of implementing such plans has deterred those in authority from adopting them. Yet had the congestion foreseen by their originators really begun to develop one or other of those plans would have had to be adopted. For there is obviously a limit beyond which, however costly the remedy, it must be adopted. In fact, however, the reason why some major improvements (such as the building of the Victoria Embankment or the driving of Kingsway through a maze of narrow streets) have been made since the early part of this century within London's central area probably lies in the growth of understanding of the principles of traffic flow that has taken place in the interior. Studies of traffic flow show, for example, how high is the capacity of streets ; and how it is the junctions, and the presence of parked vehicles that slow up the flow. It has been discovered how effective colour light signals can be in raising the capacity of junctions far above those realisable under the human control of the police ; how the adoption of the roundabout principle (providing the roundabout can be made of sufficient diameter) can make the capacity of a junction approximate to the high capacity of the streets that debauch upon it ; how the making of one-way streets can decrease the number of places at which one line of traffic has to cross over another ; and how the banning of certain right-hand turns can similarly ease traffic flow. In short, the flow of traffic has become, within the last forty years, a scientific study. Through the application of that study it has proved possible, over a long period of years, during which traffic flow in central London has almost continuously mounted, still to keep the traffic moving despite no more improvement of streets and their layout than the occasional widening of some of them, and the provision, replacement, or widening of certain Thames bridges. Now, however, it is very doubtful whether very much more can be expected of such methods. There are, indeed, places—there always will be as traffic mounts—where the provision of new lights, the declaration of one-way streets, modifications to create roundabouts will prevent congestion developing. But in the central areas (and in many areas that are not so central) about as much has already been done as it is reasonable to suppose can be done. One of the consequences is that, having as their primary concern the necessity of keeping traffic moving the police have been driven to harrying private motorists and drivers of delivery vans and making ever less space available for the parking of cars, a situation made all the worse in that rebuilding upon many bomb-sites is making off-street parking more difficult to find and must eventually, by drawing more traffic to the central areas, make the need for improvement more acute.

The members of the London and Home Counties Traffic Advisory Committee, whose twenty-eighth report was published last week, are very obviously deeply concerned about the situation that is developing. They remark, for example, that the necessity of imposing severe restrictions on certain kinds of traffic during the Coronation period of last year showed " how the mobility of London traffic can be seriously threatened by an influx of vehicles small in relation to the total number of vehicles in circulation in the area " and " how close is the margin between free traffic flow and congestion in the central area." They press firmly for the taking of a number of minor actions which they recommended in 1951, but all of which have not yet been implemented. They stress once more the growing necessity for the provision of off-street parking places. But they obviously believe that such minor action cannot do much to relieve the situation in the central area. The Committee would like to see reconsidered the whole project for the " A " ring road—a project which invoked the construction of something approaching a motor-way partly in cutting, partly in tunnel and partly on viaducts along a circuit of about 2 miles radius with Waterloo Bridge as centre. The purpose of the road would be to divert traffic from the centre of London. It would unquestionably be very expensive. But it is equally dubious whether any expenditure upon a lesser scale will be able to solve the problem.

COAL

The National Coal Board's report for 1953, which was published at the end of last week, is somewhat like the proverbial curate's egg—it's good in parts ! After providing £16,500,000 for interest payable to the Minister of Fuel and Power, the Board finished the year with a surplus of £353,647. The preceding year ended with a deficit of £8,200,000, so that, looked at from a purely financial angle, last year's result was more satisfactory, though in order to " break even " the Board had to increase coal prices. By achieving a surplus last year, however, the deficit accumulated since nationalisation was reduced to £13,600,000. Other matters in the report which give cause for a measure of satisfaction are the reduction in the number of accidents occurring in the mines, and the better progress made last year with colliery reconstruction and improvement. Last year, the Board was able to spend £64,300,000 on capital account, compared with £48,600,000 in 1952, which meant, despite increased costs, that rather more could be accomplished in the way of technical improvement. The report says that progress has continued to be made with the mechanisation of coal getting and other operations at the face, and with the many other technical developments which the Board has in hand. Much of this development work is, of course, of a long-term nature, but it is none the less disappointing that the progress so far made is not more clearly reflected in the productivity of the coal mining industry. For last year's output of deep-mined coal, at 212,500,000 tons, was 1,800,000 tons below the total raised in 1952,

although the number of face workers was higher than in any year since vesting day. Overall productivity at the mines showed no appreciable improvement, with the result that the loss of output caused by the extra week's holiday, granted for the first time last year, was not fully made up.

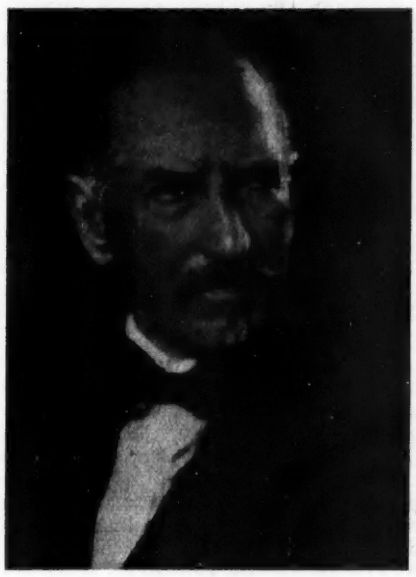
In the introduction to its report the Board emphasises that " the problems of mining coal in Britain, far from diminishing, increase with the years," and that " much still remains to be done, in a hundred and one directions, to improve the efficiency of the industry." The problems of mining coal are certainly a matter of concern at the present time. Even if last year's operations in the coal mining industry are considered as moderately satisfactory, the same cannot be said of this year's performance to date. In the first nineteen weeks of this year the output of deep-mined coal amounted to 81,677,100 tons, which was about 100,000 tons less than in the corresponding period of last year. Colliery disputes so far this year have caused a loss of deep-mined tonnage estimated at 594,600 tons, and very soon now the holiday season will be starting. However hopeful, therefore, one may be about the joint efforts of the Coal Board and the mineworkers to increase production, it is difficult to think otherwise than that this year's total output of coal will fall behind that achieved in 1953. That is a situation which industrial and all other coal consumers cannot view with equanimity ; it is a situation which undoubtedly represents the foremost of the " problems of mining coal in Britain." Side by side with the decline in output over the past few months there has been, in this country, increased consumption compared with last year. Inland coal consumption in the first eighteen weeks of the year was, at 81,012,000 tons, about 2,300,000 tons greater than in the corresponding period of last year. Industry generally supports fully the desire of the Coal Board and the Ministry of Fuel and Power that the country's coal shall be used to the best advantage, and in recent years considerable progress has been made with measures to ensure the more efficient use of fuel. But coal consumption is, of course, influenced by the level of industrial activity, and industrial activity this year has, happily, so far been at a higher level than last. It would be nothing short of a disaster if industrial activity had to be restricted because of any uncertainty, however slight, about adequate fuel supplies.

There is no doubt that the gravity of the present unsatisfactory position is keenly appreciated by the National Coal Board and by the officials of the National Union of Mineworkers. When, last January, a wage increase was granted to the miners, there was joint agreement that " a 2½ per cent increase nationally in production in 1954 with existing underground manpower was a reasonable minimum aim." The Board and the union resolved to take all practicable measures to attain that object and undertook to " review progress " at the end of every three months. The 2½ per cent increase in output would mean approximately an additional 5,000,000 tons of coal this year, but when the Board and the union leaders met last week for a review of the past three months, it was, alas, not possible to report any progress to that end ; it was very necessary, in fact, to discuss the lag in production. As we go to press, the union executive is considering the sorry state of affairs and another meeting with the Coal Board is imminent. Just what the result of these deliberations will be, in terms of a greater tonnage of coal, it is not possible to conjecture. One thing, however, is becoming abundantly clear. In the words of last year's report, " only by hard work and devotion to duty, day in, day out, on the part of everyone in the industry can the rate of output be prevented from falling." That is a depressing conclusion. For it is necessary to do more than prevent the present rate of output from falling. It needs to be increased—now.

Obituary

F. M. G. DU-PLAT-TAYLOR

On Saturday, May 22nd, the death occurred of Mr. F. M. G. Du-Plat-Taylor, who was seventy-five years of age. Mr. Du-Plat-Taylor was well known as an authority on dock and harbour engineering and had practised as a consulting engineer in that field. He was educated at Farnborough School and Winchester College, and received his technical education and training at



F. M. G. Du-Plat-Taylor

University College (London University), where he graduated in 1896, and as a pupil of A. G. Lyster, a past-president of the Institution of Civil Engineers.

In the first years of the present century Mr. Du-Plat-Taylor was employed on the engineering staff of the Mersey Docks and Harbour Board. In 1904, however, he joined the staff of the London and India Docks Company, and became resident engineer on the East and West India Docks ; he continued to work in this capacity when the Port of London Authority was formed, and obtained further experience as resident engineer at Tilbury, where his duties included supervision of the construction of the Tilbury main dock extension and a deep water jetty, founded on reinforced concrete piles, driven inside cylinders sunk down to ballast. With the constructional works at Tilbury well advanced, Mr. Du-Plat-Taylor joined the Royal Artillery, Territorial Army, in 1916. After the war he returned to his old post with the Port of London Authority, where he served until 1924. At that time he started work as a consulting engineer and continued in practice for many years, in partnership with Dr. Cunningham for part of the time, but later on, on his own. His practice included many harbour and maritime works, involving maintenance as well as new construction, and including sea defence schemes. Some of this work formed the subject of papers which Mr. Du-Plat-Taylor presented to the Institution of Civil Engineers (he was elected to membership of that Institution in 1919), including " The Prevention of Coast Erosion " (*Journal, I.C.E.*, Vol. 15, November, 1940) and " The River Rother Improvement Works " (*Selected Engineering Papers No.* 97, 1930) ; his earlier work at Tilbury was recorded in the paper, " Extensions at Tilbury Docks, 1912–1917 " (*Proceedings, I.C.E.*, Vol. 215, 1922–23). Mr. Du-Plat-Taylor's book, " Docks, Wharves and Piers," in its various editions, is well-known as a standard work of reference on that subject. He also wrote a volume entitled " The Reclamation of Land from the Sea," and he was a contributor to this journal.

The breadth of Mr. Du-Plat-Taylor's experience may be illustrated by pointing to some other of his activities. He carried out arbitration work and was a fellow of the Institute of Arbitrators. He was also a Justice of the Peace. He had many connections with civil engineers in France, and he was an Officier d'Academie, and a past-president of the British section of the French Society of Civil Engineers. He was a member of the Institution of Mechanical Engineers, and of the Association of Consulting Engineers.

Literature

Statistics for Technologists. By C. G. Paradine and B. H. P. Rivett. London : The English Universities Press Ltd., Saint Pauls House, Warwick Square, E.C.4. Price 25s.

There are now many books on elementary statistical methods on the market and it is pertinent for a reviewer to decide in what respect a new book differs from those already available. In a subject constantly developing along both theoretical and practical lines it is natural that there will be changes in emphasis and illustrative material. Further, an author's selection from the subject will depend on the kind of reader he is addressing, economists obviously requiring something different from agronomists and so on. This book is addressed to " technologists," a term which is all too comprehensive and to the reviewer means almost any sort of applied scientist or engineer. From the title of this book one would expect it to be a general introduction to the subject with a special leaning to the physical and industrial in its presentation, and this is, in fact, what it is. It is only fair to point out, however, that practising (i.e. non-student) technologists without a previous reading of the subject will find this a heavy-going introduction if they are not mathematically inclined. Although the mathematics is not advanced, the mathematical spirit prevails in the treatment. It has to be recognised, for example, that the suffix notation of the analysis of variance (e.g. x_{ijk}, $x_{.j.}$) unfortunately looks abstruse, although it can be mastered with a little persistence by anyone. The writers may retort that technologists are an intelligent section of the community and

why should they be spoon-fed ? The answer to this is : if your technologist is an engineering student, all well and good ; he will derive great benefit from the book and will usually have a lecturer on hand who can clear up difficulties ; but if the technologist is somebody engaged in industry who wishes to get some idea of what statistics can do to help him in his job, this book is written in a too academic spirit. As a textbook for someone with an already formed interest in the subject, for students, and for future statisticians preparing for the Royal Statistical Society and Incorporated Statisticians' examinations, this book deserves high praise. Its language is clear, its worked examples numerous and it has the essential qualification of a good textbook, and plenty of problems of an illuminating sort for practice, quite a number of them taken from the examination papers of the two bodies mentioned above.

The scope of the book comprises : frequency distributions, probability, the Binomial, Poisson, Normal and χ^2 Distributions ; Student's " t " and the F-test are dealt with in one chapter, followed by a chapter each on Quality Control and Sampling Inspection Schemes (both good) ; then follow chapters called " Theory of Errors," " The Method of Least Squares," and " Correlation " ; there is a fairly long chapter on " The Analysis of Variance," and the book ends with one on " Maximum Likelihood and Probit Analysis." In this development the nature of a statistical test is not gone into explicitly, and bearing in mind that a worthy exposition of this subtle subject is out of place in a book of an elementary sort, the reviewer thinks some mention should have been made of first and second kind errors, particularly in view of the chapter on Sampling Inspection Schemes, which provides such a good practical illustration. Otherwise there is little to say but praise. The chapters on the Theory of Errors and Least Squares are a useful feature of the book, and the reviewer has not seen anything similar in a general textbook. Historically, this part of the subject is older, stemming from Gauss, and omitted by most textbooks which keep to what might be called " Fisherian " statistics. The chapter on the analysis of variance is particularly good, with the reservation already noted. Fairly complex numerical examples are worked out. It seems inconsistent that after avoiding the complexities of critical regions, &c., the authors should finish with the highbrow subject of Maximum Likelihood and Probits. Would it not have been better to finish with a little about Randomised Blocks and Latin Squares, or alternatively a chapter on the application of the analysis of variance to sampling ? However, this is a matter of opinion, and as it is, Mr. Paradine and Mr. Rivett have produced a book that deserves to be widely read among students and also among technologists who have got past their statistical teething stage.

BOOKS RECEIVED

Questions and Answers on Distribution and Use of Electric Power. By T. H. Carr. London : George Newnes, Ltd., Tower House, Southampton Street, W.C.2. Price 6s.

Water Engineer's Handbook, 1954. Compiled by the staff of *Water and Water Engineering*. London : The Colliery Guardian Company, Ltd., 30 and 31, Furnival Street, Holborn, E.C.4. Price 18s.

Handbook of Industrial Electroplating. Second edition. By E. A. Ollard and E. B. Smith. Published for *Metal Industry* by Iliffe and Sons, Ltd., Dorset House, Stamford Street, London, S.E.1. Price 30s.

Characteristics and Applications of Resistance Strain Gages. Proceedings of the N.B.S. Semicentennial Symposium on Resistance Strain Gages. America : U.S. Government Printing Office, Washington 25, D.C. Price 1·50 dollars.

Letters to the Editor

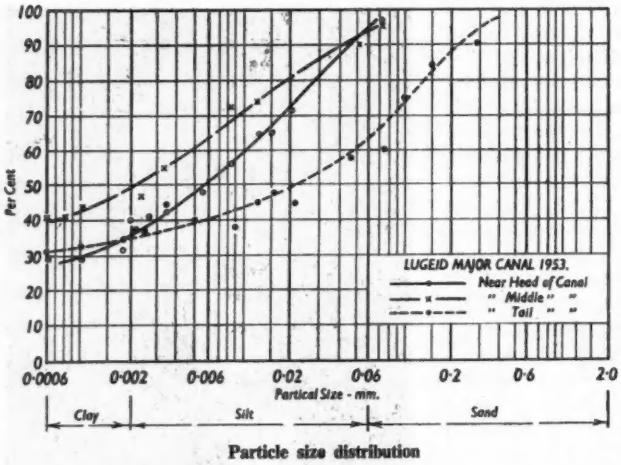
(We do not hold ourselves responsible for the opinions of our correspondents)

REGIME FLOW IN A SILT-CARRYING CHANNEL

SIR,—A reply to the letters of Sir Claude Inglis and Mr. Gerald Lacey, published in your issues of August 14 and August 28, 1953, has been long overdue. In apologising for the delay, may I say that, in the interim, samples have been obtained from the bed of the canal as requested by Sir Claude. The samples were from near the head, middle and tail of the canal, and the mechanical analysis for each is shown on the attached diagram. There is some variation which may be partly due to the small quantities in each sample. However, they give an indication of the particle sizes, and it will be noticed that at least 35 per cent is so fine as to classify as clay.

Unfortunately, the samples were taken at the end of the irrigation season, after the canal had dried out. For some months previously canal velocities would have been so exceedingly low as to be deemed almost stagnant, and fines which would otherwise never have settled have evidently done so. From the point of view of the Lacey theory, as applied here, it would seem proper that these fines should be ignored.

It is fair to assume that finer particles will have settled out mostly in the upper half of the canal during the low factor



Particle size distribution

period, so that the grading curve for the tail of the canal is the one most applicable to high discharge conditions. Apart from the clay fines, which would normally have been in suspension, a mean particle size may therefore be taken as 0·06mm. On this basis, and had the canal been in true theoretical Lacey regime, the Manning roughness would then be obtained thus :—

(*a*) $f = 1{\cdot}76\, m^{\frac{1}{2}} = 0{\cdot}431$

(*b*) $N_a = 0{\cdot}0225\, f^{\frac{1}{2}} = 0{\cdot}0182$

(*c*) Manning's $n = \dfrac{N_a}{R^{\frac{1}{12}}} = 0{\cdot}0193.$

This is rather less than the actual roughness, quoted in my article (your issue of July 10, 1953), which was 0·0214. It would seem, therefore, that Mr. Lacey is perfectly correct in his letter when he suggests that the canal was not in true regime. As he says, it had banks, and even though these were set well back they exercised a restraint which would not have been present in a river flowing freely through an alluvial plain of its own making. The channel would, however, be termed a " regime channel " in normal irrigation parlance, in India or the Sudan, in the sense that it had taken up a type of regime slope and section as a result of which neither silting nor scouring occurred.

It will be appreciated that the intention of the article was merely to demonstrate in a practical way that the Lacey equations had an easy and ready application to regime channels, and in this particular case with a remarkable degree of accuracy. In this sense the implications of f in terms of particle size and charge were beyond its scope. But obviously, in fundamental considerations of silt movement, particle size must be a basic and essential dimension, and if it can be linked with a silt and charge factor a much wider field of useful application follows. It is hoped the samples may prove to be of some value in elucidating the complexities of this subject.

Sir Claude Inglis very rightly points out that the Lacey area of cross section could have been obtained more directly by using the A, Q and f relationship. But, in the interests of simplicity, and in view also of other possible applications, only the commoner Lacey equations were referred to in the article.

In conclusion I would like to thank Mr. Lacey and Sir Claude Inglis for their valuable remarks, which have so much enhanced the value of the original article.

J. F. COOKE

Cambridge, May 11th.

UNIFIED SCREW THREADS

SIR,—Mr. B. B. Bateman's letter in THE ENGINEER of May 14th contains errors both of fact and of implication. The unified thread introduced a radiused root to an American thread, and made various alterations to tolerances and allowances which, in fact, have been found to be of sufficient importance to be considered for addition to existing Whitworth standards.

The international adoption of a unified thread is a matter of considerable consequence which those who have some knowledge of the problem fully appreciate. The inflexible and intolerant attitude adopted by others who echo Mr. Bateman's sentiments gets no one anywhere, least of all Mr. Bateman and his friends. The unified thread is a better thread than the Whitworth; its adoption is essential in the military sphere and highly desirable in many others ; that it is interchangeable with normal American threads is both expedient and sensible.

This country has not a very good record for rational thinking on screw threads ; we have B.S. Whit., B.S.F., B.S. Cycle, B.A., B.S.P., Brass, Copper and others—with angles of 47½ deg., 55 deg. and 60 deg. Will not a concentration on a single 60 deg. form, a single series of diameters and a choice of pitches eventually lead to better things ?

H. G. CONWAY

Belfast, May 19th.

SIR,—Mr. Bateman's very excellent letter on the above system in your issue of May 14th serves a very useful purpose in calling general attention to points which must already be evident to those engineers who have experience of both English and American screw thread systems.

Let us hope that at least his plea to forget the name " Unified " in connection with the new system will be accepted.

GEOFFREY K. KING,
A.M.I.C.E., A.M.I.Mech.E., A.M.I.E.I.

Norwich, May 21st.

International Railway Congress, 1954

No. I

The choice of London as the meeting place for the International Railway Congress of 1954 was particularly opportune, as the meeting was convened for a time when the organisation of British Railways would be under review. At this Congress subjects, both administrative and technical, that are of deep concern to the home railways are discussed on an international basis, while distinguished foreign visitors are being given the opportunity of seeing some of the latest railway achievements in Great Britain.

WHEN the Belgian railway jubilee was celebrated in 1885 the Government of that country sponsored the founding of the International Railway Congress Association. The purpose of the Association is to further the progress and development of railways by the holding of periodic congresses. They are held every four or five years, but in addition the Association issues a monthly bulletin, in English, French and German in which current railway topics are discussed and members of the Association kept thereby in close touch with developments in all parts of the world. While the European railways take a major interest in the proceedings, membership of the Association extends to railways in fifty countries. In the present Congress were gathered together some 450 delegates, and in Church House, Westminster, on Wednesday, May 19th, the opening ceremony was performed by H.R.H. the Duke of Gloucester.

While such a ceremony was naturally the occasion for some graceful speeches, it was, we think, notable that all three of the principal speakers—the Duke himself, Mr. Lennox-Boyd, and Sir Brian Robertson—all touched upon the value of human relations in the working of railways. THE ENGINEER, as its name suggests, is as much concerned with the man himself as with his problems and technical achievements, and it was particularly interesting to hear the Minister of Transport say : " We fully recognise, not only the interest, but also the value to ourselves and other countries of these gatherings of experts in all branches in railway management, operation and engineering, where the fullest knowledge is brought together and the results of experience acquired under great variety of conditions are interchanged. Nowhere more than among railwaymen is such readiness found to put their experiences at the disposal of their fellows most generously and without reservations. Indeed, I think it may be said that the common bond of the railway service transcends nationality."

Sir Brian Robertson, Chairman of the British Transport Commission, in referring more particularly to Britain's proud heritage in her railways, spoke broadly of important developments now under discussion ; and while his words were couched necessarily in rather general terms, they were encouraging in the forecast they gave that the ban on major capital developments is now almost at an end. Sir Brian said : " The pioneer must always be alert to ensure that the methods and techniques of the early exploratory days are not accepted without challenge as a pattern for all time. The British Transport Commission, in confirmation of their faith in the future of railway transport, believe that the stage has been reached when imaginative and bold measures should be adopted for modernisation and development on a large scale. They believe that there is a sound economic case for such measures in the interest of traders, of passengers and of the well-being of the nation, and they have recently set themselves the task of formulating a plan to this end. This great Congress will, fortunately, provide the opportunity for the members and officers of the Commission frankly and freely to discuss with their colleagues from overseas all the advances that are now being made, or that are in sight, in the operating, engineering and commercial aspects of railway work."

With the immediate formalities over, Sir Brian spoke again as Chairman of this Congress, and his hearers were deeply moved when he told in a few simple words something of the wartime history of Church House, where the Congress is being held. The Houses of Parliament were severely damaged by air attack, so much so that the House of Commons had to meet elsewhere ; and it was in Church House, in the Hoare Memorial Hall where the delegates registered, that the Commons met. Here, on a plaque in the Hall, is recorded a famous passage from one of Sir Winston Churchill's greatest wartime speeches.

The technical meetings of this Congress, which extended over five days, covered five broad aspects of railway engineering, operation and administration as follows :—

Section 1 : Way and Works ;

Section 2 : Locomotives and Rolling Stock ;

Section 3 : Working ;

Section 4 : General : administration, staff, and so on ;

Section 5 : Light Railways and Colonial Railways.

These technical discussions, which took place in the mornings, were supplemented by a comprehensive series of visits to installations of outstanding interest lying within reach of an afternoon's trip from London. These visits catered admirably for the individual interests of the technical divisions of the Congress, though a predominantly civil engineering visit, such as that to the protection works against sea erosion at Folkestone was not necessarily confined to those participating in the discussions of Technical Section 1. The same applied with all other visits. Delegates were able to see the Liverpool Street-Shenfield electrified lines of the Eastern Region, to visit the recently completed 50-cycle conversion scheme of the Southern Region suburban electrification, while steam locomotive interests were admirably covered by visits to Swindon works and to the locomotive testing station at Rugby. The intensity of passenger service provided on the railways of London Transport is unique, and overseas visitors were able to see at Acton and Lillie Bridge the shops where rolling stock, permanent way and signalling equipment is maintained to render the incomparably safe and efficient service that is now taken almost for granted on these railways. At the week-end of May 22nd and 23rd, some fine long-distance excursions were run for the benefit of delegates, including two non-stop expresses from King's Cross to Edinburgh. Leaving London around 8 a.m. and running to the 6¾-hour " Elizabethan " schedule, the visitors reached Edinburgh in good time for an afternoon sightseeing tour of the Scottish capital, prior to a long day's tour on the Sunday. Throughout the Congress, indeed, business and pleasure were happily blended.

Of the various technical visits, however, the British Railways exhibition at Willesden probably proved of the greatest all-round interest, since here delegates were able to examine at their leisure the latest locomotives, rolling stock, permanent way equipment, and signalling. This exhibition has, indeed, since been opened to the general public. While the majority of the exhibits will be familiar to readers of THE ENGINEER, there were some major items seen for the first time : the 2000 h.p. diesel-electric main line locomotive and the prototype class " 8 " express passenger " Pacific " engine recently completed at Crewe. So far as motive power is concerned, this exhibition, it can be said, looked to the future rather than represented the power that is carrying an overwhelming proportion of the traffic to-day. The fine 2500 h.p., type C_0-C_0 electric locomotive for the Manchester-Sheffield line may well be the shape of things to come, while the main line " diesel," and the gas turbine remain largely experimental. Although they are mostly at work in relatively small numbers so far, examples of the full range of new British standard steam locomotives were displayed, and although it would have been a pleasant gesture to include such old-time stalwarts as a Gresley " Pacific," and a Collett 4–6–0 of the former Great Western Railway, delegates to the Congress were able to see many of the latter in full detail at Swindon works, with one running on the stationary testing plant there, while other delegates would be able to note the prowess of the streamlined " A4 " class in the haulage of the non-stop Edinburgh specials on Saturday, May 22nd.

The new main line diesel-electric locomotive, No. 10203, is a development of the previous Southern 1750 h.p. machines. It has the 1–C_0–C_0–1 wheel arrangement, and the tractive effort-speed curve shows values of approximately 30,000 lb at 20 m.p.h., 15,000 lb at 40 m.p.h., and 8000 lb at 70 m.p.h. With a theoretical drawbar pull of 3½ tons at 70 m.p.h. No. 10203 should be an extremely powerful and effective unit. The prototype class " 8 " steam passenger locomotive has roughly the same capacity—probably rather more at higher speeds. Named " Duke of Gloucester " after the Honorary President of the Congress, this new locomotive No. 71000, is styled to look very much like the " Britannia " class in outward appearance, but three cylinders are employed instead of two, the British-Caprotti valve gear is used, and while the boiler barrel is the same the firebox is somewhat larger than that of the earlier engines. Very careful attention has been given in design to all matters governing accessibility of working parts and the ingenious method of providing access to the inside cylinder was the subject of much favourable comment. As the latest example of the British express passenger steam locomotive all details of No. 71000 will be studied from every conceivable angle by locomotive engineers, apart from the official Congress delegates, and we hope to describe it in full detail in a later issue of THE ENGINEER. Novel also in the realm of motive power was the experimental 6600V, 50-cycle motor coach, one of a set now in use on the Lancaster and Heysham electrification, on which the properties of high-tension supply with its relatively simple catenary supports are being examined by British Railways.

A fine range of modern freight wagons was

displayed, including many special purpose vehicles, but especially interesting were the many items of equipment used for mechanised maintenance of the permanent way. Among these may be mentioned the Western Region track relaying machine, capable of laying in preassembled sections up to 60ft long ; the Matisa ballast cleaner, the tamping machine, and the ballast scarifier. In view of the discussions taking place in the Way and Works Section on the effects of mechanisation, and other associated problems, these machines became the objects of special attention during the visit of the Congress delegates. Closely associated with the permanent way were many items of signalling equipment, though here, in contrast to the exhibits of locomotives and rolling stock, the apparatus was mostly such as has been in fairly general use for power signalling for several years. There are variations in detail, though on the other hand the coded track circuit is still something of a novelty so far as British practice is concerned. In America it has been widely adopted for the operation of continuous inductive cab signalling systems, but in this country the particular advantage of coded track circuits that seems likely to be of the greatest benefit is that considerably longer tracks can be satisfactorily worked. With the introduction of intermediate section colour light signals in certain localities on what are ordinarily manual block routes coded track circuits may well prove very advantageous.

Freight wagons do not come very much into the public eye, but the exhibition at Willesden showed clearly how much careful design has been devoted to the development of vehicles both for general and special duties. The need to convey the maximum possible load in mineral wagons is reflected in the design of the new 16-ton and 24½-ton units, and the tendency to introduce mechanised handling of bulk loads, with the aid of tipplers, belt conveyors and so on, is followed by the ample provision of hinged and flap doors. Wagons for more specialised traffics were to be seen in the 20-tonner for bulk grain, hoppered with a single 1ft 3in square outlet for discharge, and another very distinctive design in the 24-ton hopper wagon for conveyance of chemicals in bulk. It is interesting to see a timbered wagon retained in the standard range of freight vehicles, as being especially suitable for traffic such as potatoes and vegetables, which are likely to be affected by abnormally low temperatures. One of the most highly specialised vehicles recently introduced in British Railways was not represented in the Willesden exhibition ; this is the high-capacity iron ore hopper wagon for the traffic between Tyne Dock and the Consett Ironworks. A number of these vehicles have been built at the Shildon wagon works of the North-Eastern Region ; they have a tare weight of 24 tons, are rated to carry 56 tons of ore and are fitted with continuous brakes, for ease of train handling on the severe gradients over which the traffic is worked, and compressed air for power release of the hopper doors.

There is, however, a limit to what can be shown in one exhibition, as there is in the number of organised excursions that can be run during the immediate duration of the Congress. But with the travelling facilities afforded to delegates by British Railways no doubt many will stay a little longer in this country, and see for themselves some of the major engineering works that lie further from London than could be accommodated in an afternoon's tour. One thinks of the tunnel works at Woodhead, on the Manchester-Sheffield line, the fully mechanised freight marshalling yards at Hull and Toton, and the signalbox at York ; while with the approach of Whitsun some of our overseas visitors may witness what is one of the greatest spectacles afforded by British Railways—the handling of holiday traffic at Waterloo on a Bank Holiday week-end.

In some further articles we shall refer to the technical meetings that took place during the five business days of the Congress.

(To be continued)

Automatic System for Mass Production of Electronic Devices

(By Our American Correspondent)

The Bureau of Aeronautics of the U.S. Navy has released certain information concerning an automatic production line for the manufacture of electronic devices and a system of electronics design which makes this possible. The development of the system took place at the National Bureau of Standards under the sponsorship of the Bureau of Aeronautics. The system has been code-named "Project Tinkertoy," probably because it is based on the principle of the building blocks with which children play.

AT present, the primary purpose of the system known as "Project Tinkertoy" is to produce parts that have to be connected electrically and mechanically with electronic valves, but it could be extended to include other factory processes. The U.S. Navy is interested particularly in electronic devices relating to guided missiles, radar apparatus, proximity fuses, firing controls and communications equipment, and "Project Tinkertoy" was developed primarily to make the parts and circuits required for such units.

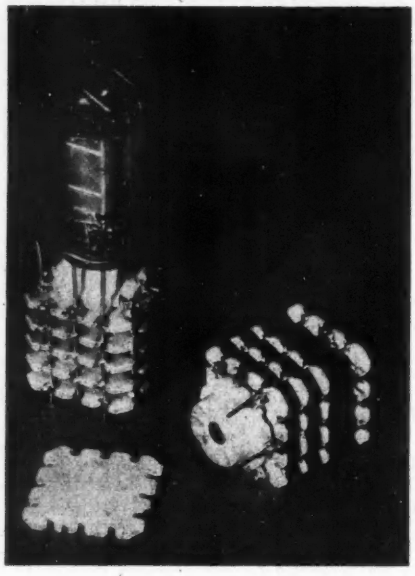


Fig. 1—Module sub-assemblies and individual wafer

Starting from raw or semi-processed materials, the machines which have been developed automatically manufacture ceramic materials and adhesive carbon resistors, print conducting circuits, and mount resistors, capacitors, and other "miniaturised" component parts on standard uniform steatite wafers. The wafers are stacked very much like building blocks to form a module that performs all of the functions of one or more electronic stages. Automatic inspection machines check the physical and electrical characteristics of the wafers at numerous stations along the production line. The completed module is a standardised interchangeable sub-assembly combining all of the requirements of an electronic circuit with ruggedness, reliability and extreme compactness.

"Project Tinkertoy" was begun at the National Bureau of Standards in May, 1950, and now successfully produces electronic sub-assemblies by mechanised means. The pilot plant, which is situated at Arlington, Virginia, is operated by a commercial contractor, the Kaiser Electronics Division of the Willys Motor Company, as part of a large-scale production evaluation programme under the technical direction of the N.B.S. The key to the automatic mechanised production of electronic equipment employed is the design system involved. Called "M.D.E."—for modular design of electronics—the system established a series of mechanically standardised and uniform modules which may be produced with a wide range of electrical characteristics.

Each module, in general, consists of some four to six thin ceramic wafers, bearing various circuits which are associated with an electronic stage. Two representative modules and an individual ceramic wafer are illustrated in Fig. 1. A number of individual modules are combined to form a major sub-assembly. The composition of modules into major sub-assemblies of electronic equipment is possible because, generally, there is great similarity between circuits and parts of circuits in modern electronic equipment. To-day, electronic assemblies consist largely of electronic valves and arrays of simple resistors and capacitors which account for the mass of the individual parts and are also responsible for the bulk of the manual production effort in conventional manufacture.

The production of modules and assemblies, which have been designed in accordance with the "M.D.E." system, is achieved mechanically

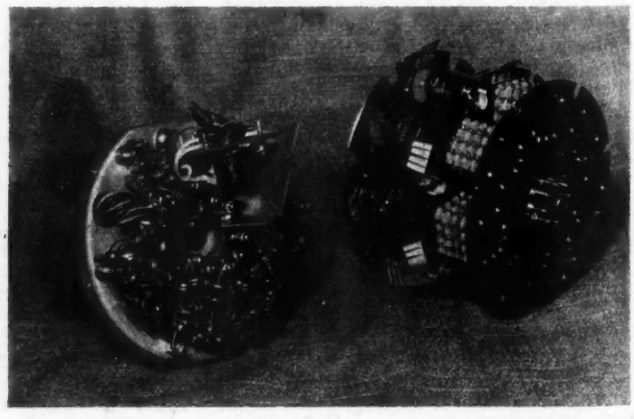


Fig. 2—Comparison of conventional assembly (left) with "Project Tinkertoy" assembly (right)

Fig. 3—Pilot production plant at Arlington, Virginia

by means of a production system known as "M.P.E."—mechanised production of electronics. Under this system, the ceramic wafers, which are ½in square by $\frac{1}{25}$in thick, are produced directly in quantity from raw materials. Ceramic capacitors are produced in a similar fashion, and another part of the production line produces adhesive tape resistors. These and other basic parts are fed into the assembly line. The appropriate circuits are printed by automatic machines. The circuit configuration is achieved through photographic processing. Quality control is established by automatic inspection, directed by information prepared in punched card form. The system is based on the use of bulk or semi-processed materials, and the line produces all parts required in large quantities, except for the valves. The pilot plant has been designed for a production rate of 1000 modules per hour.

Modular Design of Electronics

"M.D.E." is considered to be the basis of the "Project Tinkertoy" system. In this system interconnection is relatively simple between any number of modular units. By combining modular assemblies containing different component parts, such as resistors, capacitors, and coils, whole electronic circuits may be developed to amplify signals, generate and shape wave forms, scale count, and perform other customary electronic functions. Fig. 2 shows, for comparison, an item of electronic equipment produced by conventional assembly methods (left) and a version of the same piece of equipment produced with the aid of the "Project Tinkertoy" system (right).

The "M.D.E." system of design dispenses with the conventional circuit diagram of the tested electronic model and places all necessary production planning information on a work sheet. Each work sheet contains the front and back outlines of six wafers, appropriately numbered to identify each notch in the wafer, each riser wire, and the electronic piece that is to be placed on the wafer. The engineer translates his conventional wiring diagram to such an "M.D.E." diagram. He indicates the position of the piece and its proper value and tolerances. Lines are drawn to indicate how the circuits between the wafers are to be connected. The "M.D.E." work sheet is also used to establish the inspection procedure. Current paths on each wafer are marked on specially prepared punched cards, which accompany the wafers through all of the manufacturing processes.

Mechanised Production of Electronics

The interior of the "M.P.E." pilot plant at Arlington, Virginia, is shown in Fig. 3, while Fig. 4 is a schematic diagram of the production line employed at this plant. At present, "M.P.E." comprises the mechanised production of ceramic wafers, titanate capacitors and tape resistors and their automatic mechanical assembly and inspection. In some electronic equipment a single chassis may have as many as 100 resistors and 100 capacitors. The facilities of the present pilot plant provide for the manufacture of nearly all of these pieces from their respective raw materials. The wafers and valve sockets are made from talc, clay and barium carbonate, which, in combination, yield a ceramic with excellent electrical characteristics. The minerals are mixed, milled and dried to a flour-like consistency. Binding agents of corn flour and petroleum-base wax are added, and the mixing and drying operations are repeated. Before the final compounding, the flour is graded according to particle size. It has been found that by carefully combining particles of different sizes the ceramic product will have no laminations, be perfectly flat, and will have no air pockets within the structure. After the addition of zinc stearate, which acts as a lubricant, the powder is pressed into either one of three wafer types or a seven or nine-pin valve socket. The press exerts pressures up to 10,000 lb per square inch and can stamp 2300 wafers an hour. The "green" or uncured ceramic bodies are machine-loaded on to setter tiles, which are then conveyed through a tunnel kiln operating at a temperature of 2300 deg. Fah. The curing operation is completed in nine hours, and, after curing, the wafers are gauged in a machine that accepts all wafers no thicker than 0·0625in+0·008in and no larger than 0·875in+0·003in square. As shown in Fig. 1, the standard wafer is pressed with twelve peripheral notches as well as a keying notch. In the final module assembly, riser wires are mechanically soldered into the twelve notches and serve as physical supports for the module and as electrical connectors between the wafer-mounted circuits. The keying notch is a medium by which individual wafers are automatically oriented to facilitate the mechanical application of component parts.

The titanate body of the ceramic capacitors employed is manufactured in very much the same manner as the ceramic wafers. The capacitor is made of non-porous ceramic composed usually of magnesium, barium, calcium and strontium titanates of high purity, organic binders and water. After firing, it is about ¼in square and 0·020in thick. Its capacity may be varied from 7·0 micromicrofarad to 0·01 microfarad by changing the relative proportions of the constituent minerals. Although the manufacture of capacitor bodies is very similar to the production of the ceramic wafers, greater control must be exercised during the various operations. Thus, a rubber-lined ball mill and Pyrex drying dishes are used to eliminate the possibility of steel dust and oxides contaminating the mixture. Great care is exercised during the mixing and firing operations so as to maintain control over the shrinkage that normally occurs in the ceramic body. Because the capacitor is composed of highly abrasive and hard materials, only cemented carbide dies appear to give satisfactory long-term service. Furthermore, it was found that capacitor bodies having high dielectric constants have a tendency to decay in capacitance value with time of storage, and an adequate allowance for this decay is now made in subsequent silvering operations on the production line.

The materials required for the manufacture of the tape resistors are a heat-resistant asbestos paper tape known as Quinterra, polyethylene tape, carbon black or graphite, resin, and a solvent. The resistor formulation, which is a mixture of the carbon, resin and solvent, is ground to a fine adhesive powder. The compound is then sprayed on a loop of Quinterra tape, and a protective coating of polyethylene tape is applied. The tape is split into five or six narrow strips and stored on rolls in a refrigerator. A 75ft roll of tape will produce over 10,000 resistors. The tape resistors produced have a range from 10 ohms to 10 megohms. They will hold their rated resistance within ±10 per cent up to temperatures of about 200 deg. Fah. and are capable of ½W power dissipation at the operating temperature.

In the metallising section of the production

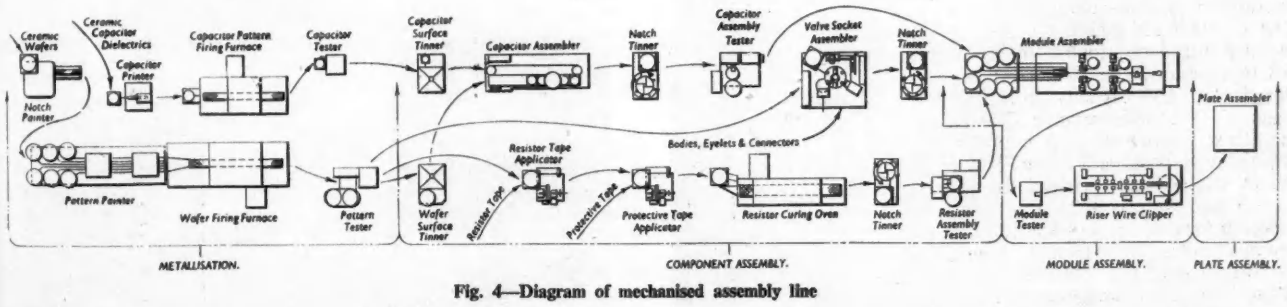


Fig. 4—Diagram of mechanised assembly line

Fig. 5—Wafer circuit printing machine and vibratory bowl feeders

line, appropriate sections of the wafer or capacitor body are silver painted. During these stages, circuits are printed on the wafers, notches are coated, conducting surfaces and leads are applied to capacitors, furnace curing takes place and the circuits are inspected. Finally, all silvered surfaces receive a thin coating of solder. The steatite wafer, which is the basic element in the " M.P.E." system, is first metallised in a machine that deposits silver paint in the twelve peripheral notches of the wafers. Chain-driven grippers then carry the wafers past four sets of printing wheels. Each wheel is composed of three discs that engage the notches on one side of the wafer in synchronism with the chain drive. Various conducting circuits are printed on the wafers in a machine which can print up to six wafers simultaneously and which is shown in Fig. 5. The patterns are photographically etched on a rectangular stencil screen and usually include the connections to which will be attached the tape resistors, valve pins, and other electronic parts. The wafers are conveyed under the stencil where chain-driven squeegees force silver paint through the patterns on to the wafers. The wafers then pass through a heater in which they are inverted and the unprinted surfaces are exposed to a second stencilling operation. After another heating and drying period, the wafers are conveyed through a firing furnace in which the silver paint is made highly conductive and is physically and chemically bonded to the ceramic surfaces. The conducting pattern for the capacitors is a solid square of silver covering most of the surface area and small tabs of silver at the four rounded corners of the body. The pattern is repeated on both surfaces of the capacitor except that one receives an additional bar of silver connecting two diagonally opposite corner tabs with the central square. Two circular stencil screens simultaneously print both surfaces of the capacitor body.

The keying notch, which is pressed into each wafer, is initially used during the metallising operations. The wafers are loaded into vibratory bowl feeders, which may be seen in the background of Fig. 5. These feeders are provided with spiral escape channels having a series of eight exit ports. A small screw is inserted into each exit port, permitting only those wafers to pass whose key is aligned with the screw. If the wafer is incorrectly oriented, it is turned through 90 deg. as it falls down the channel step following the exit port. A specially grooved channel inverts the wafer if it has failed to pass through the first four ports, and the keying procedure is repeated. As a consequence, all wafers passing from the feeders are oriented in the same direction and have the same surface turned upward. In order to control the quantity of wafers being issued from the vibratory bowl feeders the issuing channel is provided with a photo-electric cell that functions only if the light path is completed. If the channel is not filled with wafers, the completed photo-cell light path energises the circuit causing the bowl to vibrate. When the channel is full, the bowl automatically stops vibrating and, therefore, issuing wafers.

Tape resistors, titanate capacitors, valve sockets and other " miniaturised " parts are mounted on the wafers between the appropriate silvered

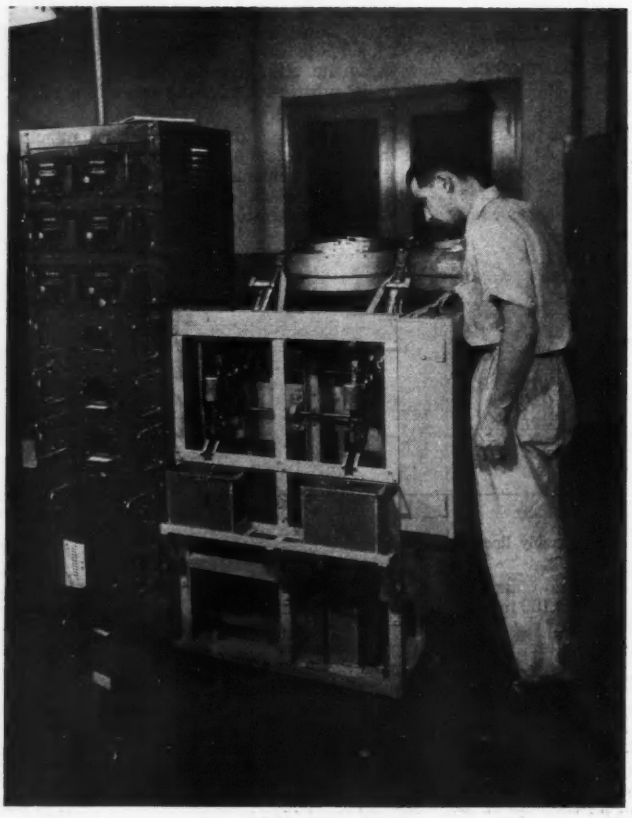


Fig. 6—Wafer inspection machine

Fig. 7—Module inspection machine

conducting patterns. Rolls of resistor tape are placed on a machine that automatically cuts the tape into ¼in lengths, presses the resistors between the printed electrodes on the surface of the wafer, applies pressure, and ejects the completed resistor-mounted wafer. As many as two resistor tapes may be applied to each wafer surface. A single machine is used to mount up to two capacitors on each surface of a wafer. Each capacitor is automatically oriented and the silvered circuit on both surfaces is electrically tested before mounting. Thus, if four capacitors are to be mounted on a wafer, the first two are dropped into a conveyor-driven jig. They are followed by a " slave " that centres the capacitors, whence the properly oriented wafer is added. The remaining two capacitors are dropped on top of the wafer. The jig is conveyed through a pair of induction heaters which cause the tinned surfaces on the parts to bond. In the valve socket assembly machine, silvered pins are mechanically placed into their proper holes in the steatite valve socket, a wafer is placed on top of the socket, and a rivet binds the two pieces together. After the various parts have been mounted on the wafers, the notches on the wafer are tinned with solder. The machine that performs this operation automatically grips each assembled wafer and dips one side into flux and solder. The tinning operation is repeated on the other three sides after successive 90 deg. turns of the wafer.

Uniform wafer-mounted component parts, including wafer-mounted coils, toroids, potentiometers and crystals are now ready for assembly. The complete assembly of the module is accomplished in a single machine, which is shown in the right foreground of Fig. 3. Six vibratory feeders issue the wafers to a loading device that holds the wafers in an upright position between specially designed jaws. A chain drive carries the jig to a soldering position at which six riser wires are guided into appropriate notches, three on a side. The mechanism brings soldering irons in contact with the unit and bonds the wires to the notches. The unit is turned through 90 deg. and the chain drive carries it to another soldering position where six more wires are bonded to the module. After final electrical inspection segments of riser wires are severed where circuit isolation is required between the wafer-mounted circuits.

Automatic Inspection

During each stage in the " M.P.E." system of production, provision is made for 100 per cent automatic inspection. This inspection comprises both a physical gauging and an electrical comparison. Printed circuits, resistors and capacitors are compared with their electronic equivalents both before and after assembly. This is accomplished by the use of electronic computers, bridge circuits, and other comparison devices. The inspection " code " is contained on the punched cards that were prepared initially by the design engineer and have accompanied the wafers all through the production process. After the final assembly of the module the whole circuit is again tested to see that it meets the appropriate specifications within set tolerances. The circuit-mounted wafers are automatically inspected in a machine which is illustrated in Fig. 6. This inspection device determines if the patterns have been correctly stencilled and if all of the wafers in a particular batch are alike. The punched holes in the inspection card electronically set up computer circuits. Thus, if two notches are to be connected by a painted conductor, the corresponding circuit in the computer is disconnected. If the printed pattern appears between the two points in question, the computer recognises it as a completed circuit and signals a relay to accept the wafer. Up to seventy-two combinations may be printed between twenty-two possible connecting points on the surfaces of a standard wafer.

The capacitor inspecting device incorporates two commercial precision capacitors with a range of from 110 to 1100 micromicrofarads and a precise comparison bridge. One precision capacitor is set at the upper tolerance limit of the required capacity ; the other capacitor is set at the lower tolerance. As the titanate bodies are ejected from a vibratory feeder, the silver surfaces are first checked for continuity. Subsequently, they are admitted to the circuit containing the precision capacitors and the comparison bridge. Only those bodies showing a value of capacity between the set tolerances are accepted. The automatic inspection of a single capacitor can be accomplished in less than half a second. After the capacitors have been bonded to their wafers, the completed unit is automatically inspected for capacity, voltage breakdown and leakage resistance. The capacitor-mounted wafers are issued from a vibratory feeder on to a turntable. Twelve fingers engage the peripheral notches on the wafer and provide conducting paths between the capacitors on the wafer and a " standard " network composed of precise conventional capacitors. If accepted, the turntable moves the wafer under another inspecting head where again the notches are engaged and voltages are applied along appropriate conducting paths. The magnitude of the breakdown voltage is determined by the actual operating conditions which the unit will undergo. The leakage resistance must be at least 8300 megohms between conducting circuits.

The resistor-mounted wafers are inspected in a machine very similar in operation to the capacitor-mounted wafer inspection unit. Prior to their application to the wafer, the rolls of tape had been tested for correct resistance. The completed wafer assembly is then automatically compared with a conventional resistor network in a bridge circuit. Finally, the completed module is inspected in a machine which is illustrated in Fig. 7. This inspection unit sequentially compares the completed module with a " standard " module composed of conventional resistors, capacitors, coils, &c., all arranged in accordance with the original " M.D.E." circuit design.

The final assembly operation need not necessarily be considered a part of the mechanised production of electronics. Normally, a set of modules is mounted on or between copper-clad base plates. Circuits have been etched into the copper surface and connect the riser wires of the several modules to form a complete electronic circuit. Several such plate assemblies may form an item of electronic equipment, as indicated in Fig. 2.

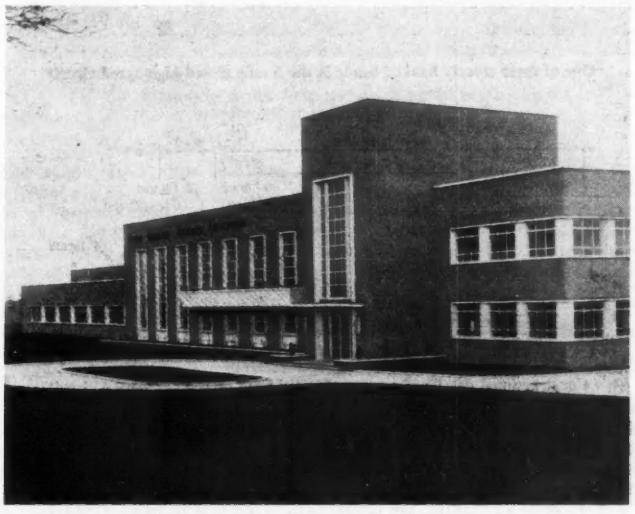
The Industrial Planning Division of the U.S. Navy has for many years been concerned with the question of industrial mobilisation and preparedness. In studying the electronic industry from this point of view, it was concluded that in the event of a national emergency the costs for production and maintenance of electronic equipment would be formidable in view of the quantities and varieties of gear needed. Consequently, it was decided that the only solution to the problems of satisfying the huge demands for electronic equipment was a mechanised production system. In its present form, the " Tinkertoy " method makes possible a rapid conversion from civilian to military products at short notice and, furthermore, allows a greatly expanded production capacity. Delays caused by the need for recruiting and training new production personnel and the procurement of new mechanisms and parts are greatly eliminated. Most of the operating " know-how " is stored in mechanical fingers and electro-mechanical control mechanisms, and even electronic equipment designs may be stored, ready for production, in the form of punched cards and circuit stencil screens.

Because " Project Tinkertoy " largely utilises unprocessed or bulk materials, the system is comparatively free from dependence on particular components which may be in critical supply in times of national emergency. The uniformity of the electronic products made is enhanced by the mechanised production and by a 100 per cent automatic inspection. The method also facilitates the repair and maintenance of entire electronic systems by the replacement of unitised packages or entire sub-assemblies.

M.I.R.A. Proving Ground

THE laboratory and proving ground of the Motor Industry Research Association at Lindley, Nuneaton, was formally opened by the Minister of Transport last Friday. This association was formed in 1946 and research and proving facilities were first installed at the disused Lindley airfield in 1949. In the course of a visit to the site three years ago, we described in these columns* the different test track surfaces and some of the equipment which was then in operation. The principal additions since then are the high-speed test circuit which was completed last year and the new central laboratories, illustrations of both being reproduced herewith.

The construction of this circuit was described in a paper presented at the Institution of Civil Engineers,† from which the diagram has been reproduced. The track was converted from the flat perimeter track of the airfield, and the super-elevated bends, a cross section through one of which is shown, can be negotiated at 100 m.p.h. with reliance on side friction to the extent of only one-sixth of the weight of the vehicle. The construction shown consists of a clay embankment with a 9in cast-in-situ concrete paving, without after-treatment of the surface : a maximum divergence of ¼in from a 10ft straight edge was specified for this construction. This stipulation was generally met, the authors noted, and in their opinion 1 in 1½ was about the greatest slope at which a reliable concrete pavement could be laid in one operation, without resort to top shuttering or subsequent surface dressing. This work is believed to be without precedent in Great Britain, with the exception of the old Brooklands race track.



Automobile research building for engine and component testing, with workshops and other laboratories

Within the main laboratory is a hall with eight fully-equipped engine test bays. Walls,

* See THE ENGINEER, July 13, 1951.

† " The Design and Construction of a High-Speed Test Track for Motor Vehicles," by R. Freeman and J. A. Neill, Road Engineering Division, December 1, 1953.

ceiling and partitions are covered with sound-absorbing materials, and the concrete beds are cushioned on rubber to reduce vibration.

Research into improving the mechanical efficiency of petrol and diesel engines is being carried out, particular attention being paid to the use of low-viscosity lubricating oils. A method of test for diesel engine lubricating oils is also being developed, the main object being to provide a test procedure for operators to assess the ring-gumming and sticking tendencies of oils in service.

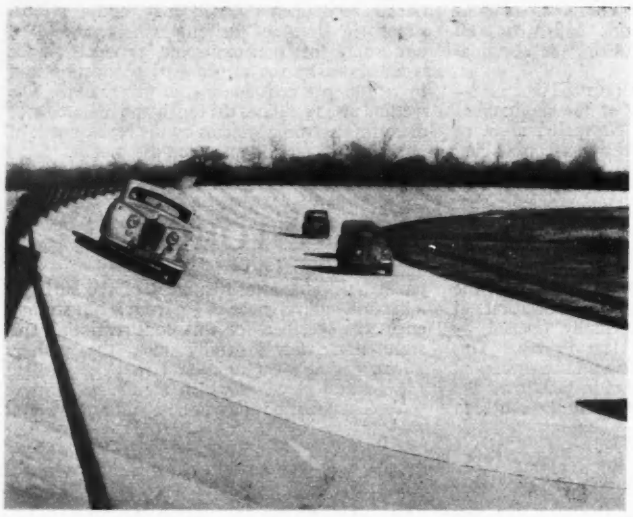
The loads to which crankshafts are subjected while running in an engine, operating under a wide variety of conditions, are being comprehensively investigated. Wire resistance strain gauges attached to the crankshaft are used for this work, and the loads are recorded photographically from the trace on a cathode-ray oscillograph.

Particular importance is attached to the results of the fatigue research programme on crankshafts in which the influence of design, alternative materials—particularly iron—and surface treatments have been exhaustively examined. Characteristic failures have been observed on both the bending fatigue and torsional fatigue testing rigs. In the former, failure occurs across the web, apparently starting from cracks originating at the journal fillets. In the event of torsional fatigue fracture also the most common failure occurs through a journal at the fillet. It has been found that work hardening these fillets by ball rolling can increase the fatigue strength by as much as 80 per cent and at the same time it appears that a considerable reduction in the size of the fillet radius will be possible also, thereby shortening the crankshaft.

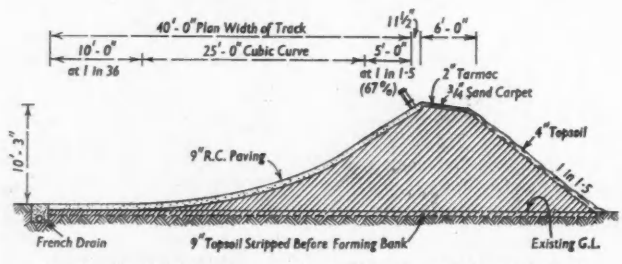
A similar programme of work is in hand in another department of the laboratory on the use of different materials—particularly low alloy steels—in the design of gear wheels. Further examples from the current research programme were illustrated by other rigs in the laboratory, notably on brake fade and squeal. The development of special test instruments is undertaken in the electronics laboratory.

A study of the complex problems of noise in vehicles is also being made, including the construction of specialised portable magnetic tape recorders, and analysing equipment. A room with all internal surfaces specially treated to give freedom from sound reflection over a wide frequency range—a "free-field" room—has been designed and built by M.I.R.A. staff to assist in these investigations. The walls and ceiling are lined with wedges, alternately oriented, filled with "Stillite."

There is a metallurgical and chemical laboratory and a machine shop fully equipped to make special apparatus, instruments and test specimens. A large garage is also extensively equipped for modifying and repairing test vehicles. Amongst other facilities within the laboratory is a comprehensive library from which is operated a postal loans service.



One of three steeply banked bends in the 3 mile closed high-speed circuit



Constructional details of a super-elevated bend on the high-speed circuit

Steel-Making Processes

In the 1954 H. M. Howe Memorial Lecture of the American Institution of Mining and Metallurgical Engineers,* C. D. King, vice-president of operations in the United States Steel Corporation, Pittsburgh, has indulged in some speculations on the future form and relative importance of various steel-making processes. During the hundred years that have elapsed since the cementation and crucible processes accounted for the whole output of steel, only three processes could, in the lecturer's opinion, be classed as revolutionary. These were the pneumatic (or Bessemer) process, the reverberatory method (the open-hearth process) and the electric furnace process. All variations and combinations of these three fundamental methods he regarded as evolutionary. The lecture gave a review of these changes and modifications, and of many recent developments, including some ideas still in their formative stages.

For nearly a hundred years the lead has been taken by the open-hearth operation which has shown that it can produce uniform results consistently with extreme variations in materials and fuels, and has demonstrated a versatility in the use of scrap and pig iron which is a most important criterion of long-term economy. Where integration is concerned there is no comparable process which possesses so many advantages and so few liabilities. These reasons are given for the conclusion that the open-hearth operation will remain the bulwark of steel-making methods for very many years to come, though cold-iron, open-hearth plants will die out. Modified duplex open-hearth operations, such as the melting of scrap in a converter by the use of oxygen-enriched air and the supply of blown metal to stationary rather than tilting open-hearth furnaces, are predicted. Electric furnaces, said Mr. King, would continue to remain supreme in the field of high-alloy steels, but increasing use would probably be made of this method in the production of carbon steel ingots in those areas in which purchased scrap was relatively abundant and power was available at reasonable cost. In addition and subject to local conditions, it might be expected that increasing use would be made of electric furnaces at already existing open-hearth plants to supplement carbon-steel ingot production.

The lecturer regarded it as most unlikely that there would be any significant expansion in the use of acid-lined Bessemer converters in the production of ingots, but that the newer modifications of the basic process would be increasingly favoured, in competition with steel plants using other processes, for the manufacture of low-carbon steels. An important future is foreshadowed for the turbo-hearth (surface blowing in a special vessel); for the modified basic Bessemer process, involving the addition of oxides, such as mill scale or ore, early in the blow, and the use of oxygen, steam or carbon dioxide, or combinations of these, in conjunction with the blown air, and for the Austrian (Linz Donawitz) process, based on the use of solid bottom converters lined with basic refractories and employing a vertically suspended, water-cooled, copper-nosed lance above the melt for the supply of nearly pure oxygen.

The lecturer's distinction between revolutionary and evolutionary processes would seem to be a little difficult to defend. The revolutionary feature of the open-hearth process, for example, might be held to be the principle of regeneration and the resulting heat economy, and not the reverberatory furnace which had been tried out in one form or another for steel-making in the previous twenty years. On similar grounds it is difficult to see why the Gilchrist-Thomas modification of the "pneumatic" process should be denied the classification "revolutionary," in view of its enormous economic effects as well as the novelty of the chemical principles on which it was based. The future prospects in steel-making, as summed up by the lecturer, are distinctly of an evolutionary character. Revolutionary developments are, perhaps in the nature of things, much more difficult to predict.

* *Journal of Metals*, April, 1954, page 455.

Work of the Bureau of Reclamation

The latest annual report of the U.S. Bureau of Reclamation states that during the fiscal year 1953 the Bureau added about 3,700,000 acre-feet of storage capacity in new reservoirs, 240MW of hydro-electric generating capacity, 700 miles of irrigation canals, pipelines and laterals, and various high-voltage electrical transmission lines. The total value of all contracts awarded by the Bureau of Reclamation during the year amounted to about 100 million dollars, comprising the face value of more than 450 separate contracts for construction, materials, equipment and supplies. Funds were provided by Congress to facilitate the start of construction on ten new projects or units. Hungry Horse dam was completed during the year.

There was a significant increase in the total irrigable land situated in the service areas of Reclamation projects. The number of irrigable acres totalled 6,994,478, equivalent to an increase of 281,463 over last year's figure. The Bureau opened for settlement 18,292 acres, comprising 263 farm units on the Columbia and Minidoka projects. A survey of representative settlers who have come to Reclamation farm units since 1946 showed that 97 per cent were still on their land.

The total installed capacity in twenty-six hydro-electric plants operated by the Bureau at the end of the year was 4421MW. The sale of electrical energy totalled 25,850,471,408 kWh, which brought revenues of 44,963,080 dollars to the U.S. Treasury. Fourteen power stations are currently under construction, and will ultimately add 526MW to the Reclamation power system.

The Grand Coulee dam contributed about 40 per cent of all hydro-electric energy used in the Pacific Northwest. Hydro-electric plants on the Colorado River—at Hoover, Davis and Parker dams and the Siphon Drop on the Yuma Project—generated nearly 40 per cent of the total energy used in the Pacific Southwest of the United States. In addition to power plants, the construction works of the Bureau of Reclamation now comprise 116 storage dams, 74 diversion dams, over 18,500 miles of canals and laterals, 5600 miles of drains, 354 major pumping plants, 8433 miles of transmission lines, and an estimated 11,000 miles of access roads.

High Density Tungsten Alloy

IN the course of a recent visit to the Osram-G.E.C. metals factory at Wembley, we were able to see the relatively large-scale manufacture of the G.E.C. Heavy Alloy, a sintered tungsten alloy, and some of its applications. Its manufacture had formerly been undertaken on pilot plant in the research laboratories of the company, the need to transfer to the present site having arisen with the demand for this metal following the derestriction in the use of tungsten. Some of the properties of this alloy are as follows :—

Specific gravity	16·5 to 17
Approximate weight	0·6 lb per cubic inch
Tensile strength	42 tons per square inch
Yield point	38 tons per square inch
Brinell hardness number	290
Coefficient of expansion 20 deg. to 420 deg. Cent.	$5{\cdot}6 \times 10^{-6}$

It will be recalled that the basic alloy was first developed by the company before the war in its attempts to use tungsten (of which it had considerable knowledge and experience) instead of lead as a radium beam therapy shield. Apart from being too soft, lead was not ideal in other properties comparable with those of the existing alloy. The G.E.C. is also developing an alloy of high density, characterised by higher elongation, with no corresponding decrease in tensile strength. This will be available in the form of sheet of a limited size.

Manufacture.—The manufacturing techniques employed owe much to the company's specialised experience with tungsten in connection with the production of filament lamps and thermionic valves.

Before the tungsten, nickel and other constituent powders of the alloy reach the processing plant they have to pass stringent specifications for their chemical and physical properties. They are then mechanically mixed, bonded with a paraffin wax binder, placed in a die (Fig. 1) and compressed, pressures being about 5 tons per square inch. The compact is then heated at a carefully controlled low temperature in continuous tube furnaces. It is now in the "green" state, and sufficiently consolidated to stand further shaping where the final contours

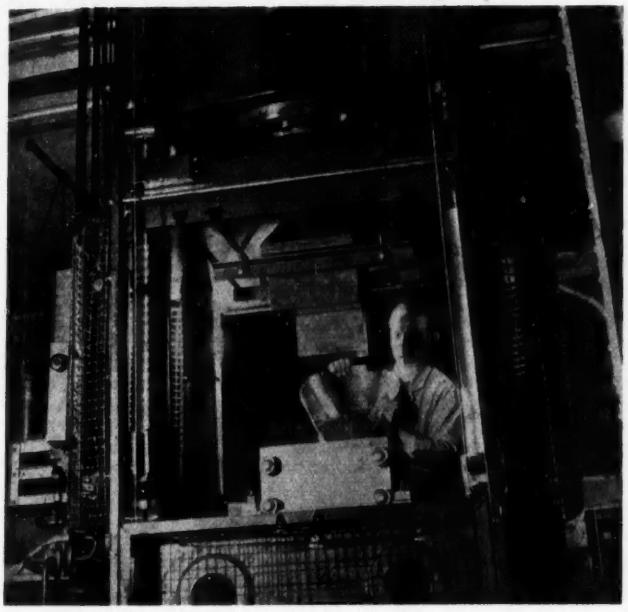


Fig. 1—The powder mix of tungsten and alloying elements is compacted in dies at 5 tons per square inch

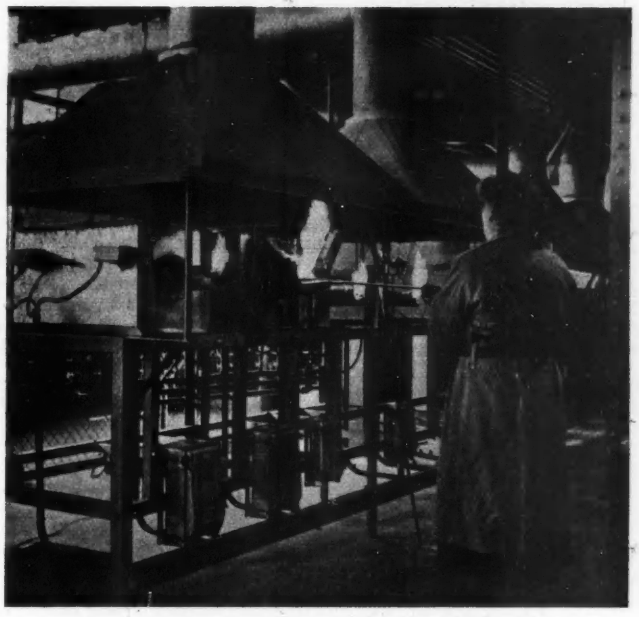


Fig. 2—A battery of muffle furnaces into which the pressed blanks are sintered at 1450 deg. Cent

respects and has a density of only 11·6 g/c.c. A radium container could therefore be made considerably less bulky in this alloy, the gamma absorption properties of lead and alternative metals being inversely proportional to their density.

Tungsten, however, lacked many engineering qualities, had a very high melting point, and was largely unworkable. These difficulties, it was found, could be largely offset by mixing with the tungsten powder up to 10 per cent of nickel and other alloying powders which formed a liquid matrix at a relatively low temperature and filled the voids.

No other use for this alloy was anticipated at that time, but upon the outbreak of the last war it was realised that by its use the mass balances associated with aircraft control surfaces could be located internally thereby effecting a drag reduction. This remains the largest application of the metal. Development of the alloy has rendered its mechanical properties suitable for more dynamic balancing applications, some of which are referred to later.

A new series of alloys are being developed with densities up to 18 g/c.c. and over, which are approaching the theoretical density of tungsten. All these alloys can be drilled, tapped, turned, ground or machined, and possess mechanical

required are slightly complicated. It is then placed in an electric muffle furnace in a hydrogen atmosphere and sintered at white heat, approximately 1450 deg. Cent. (Fig. 2).

During the sintering process the compact shrinks by nearly 20 per cent in volume, with a corresponding increase in density from 10–12 g/c.c to the final density required. This decrease in volume must be accurately predetermined within close tolerances. Since it is calculable the original dies for the powder can be designed with precision for many required shapes or sizes of sintered product.

Medical Applications.—The density of the alloy becomes of prime importance in the design of telecurietherapy apparatus, in which very large quantities of radium—or more recently, radioactive cobalt—are used. This equipment exploits the fact that the Heavy Alloy combines higher radiation absorption and better mechanical properties than lead in a material which is readily machinable and much less expensive than gold or platinum.

An illustration in the general medical field is provided by a larynx collar which has recently been constructed at the Christie Hospital and Holt Radium Institute at Manchester for treating cancer of the larynx by radium gamma rays. This machine, which is remote controlled and about the size of a large lathe, brings round the neck of a seated patient a heavy, thick lead collar in which are embedded twenty-eight gamma ray sources, containing a total of about 3 grammes of radium. The lead reduces the gamma ray intensity from each of these sources by a large factor in all directions except towards the patient's larynx, in which direction the lead has been cut away to give a radiation beam. The larynx is thus irradiated like an aeroplane in a cluster of searchlight beams, while the surrounding tissue receives a comparatively small dose.

If this collar were made entirely of lead, in order to give adequate radiation protection for the chin and head above and the shoulders and trunk below, it would be too tall to fit around the neck. The central lead portion of the collar has therefore been sandwiched between two machined pieces of G.E.C. Heavy Alloy, which, because of their higher density, give the required degree of protection with a thinner section, and at the same time provide a firm support for the comparatively soft lead.

Aeronautical Applications.—Apart from the use already referred to, there are now many more aeronautical applications, both static and dynamic. One such has been the "G" Restrictor made by British Messier, Ltd. This was a unit which warned the pilot when a critical vertical acceleration on the aircraft was reached by imposing a resisting load on the control column. Should the pilot ignore the initial resistance and impose a greater vertical acceleration on the aircraft, the "G" Restrictor developed sufficient force to move the control against the pilot's force and thus reduce the vertical acceleration.

It employed a Heavy Alloy weight, which would not have been possible to make from lead because of the electrolytic action between the hydraulic fluid used and the component. Nor was steel a practicable alternative, since it would occupy twice the space, increasing the size of the chamber where this was very limited.

In the "Maxaret" automatic brake control units, described in THE ENGINEER, October 3, 1952, the flywheel is made of this alloy. As the space between the bogie wheels of an aircraft or between the wheels and other equipment is restricted, this use of the alloy for the flywheel is imperative. Lead occupies too much space and the alternative would be to use a small flywheel with a low energy potential as a sensing unit only, controlling the brakes by electro-magnetic gear. A flywheel with a high energy/space ratio offered the advantage

that it can operate the valve by direct mechanical action rather than by an electrical impulse.

A sintered Heavy Alloy blank is made to close limits so that the flywheel can be produced with the minimum of machining. When it is received it is machined all over, has a ball race ground in it and the thin web machined away, leaving a single diametral spoke. The material is amenable to all these operations and is machined to a tolerance of 0·003in. It is sufficiently hard to form a ball race of $^{3}/_{32}$in diameter steel balls on each side of the central web, and is driven through the bosses in the central web at speeds up to 8000 r.p.m.

An even greater dynamic test of the material's strength is that to which it is subjected in aircraft gyroscopic instruments. The stability of gyroscopic movement depends on angular momentum and a maximum mass density at as large a radius as possible within the allowable limitations on physical dimensions and overall weight must be provided.

The Sperry Gyroscope Company, Ltd., now uses in its electric artificial gyro horizon for aircraft a rotor of heavy alloy instead of the former brass or bronze rotor. The rotor consists of a three-phase squirrel-cage induction motor so constructed that the squirrel cage forms a rotor which spins on a vertical axis around the stator windings. The squirrel cage is housed in a cup of Heavy Alloy, to which it is bonded with "Araldite." This method of construction ensures that the weight of the rotor is concentrated as near to the periphery as possible, and therefore provides the maximum inertia.

Tensile strength and machinability are important requirements in this application; tensile strength because the 1·87in diameter rotor must undergo a speed test at 30,000 r.p.m. without fracture, and machinability because the blank supplied by the G.E.C. is machined in the Sperry works to a tolerance of 0·006in. A hole is also bored in the bottom of the blank for the shaft of the rotor.

In the air-driven artificial horizons and the gyro direction indicators made by Smiths Aircraft Instruments, Ltd., the alloy is used in a similar fashion as a tyre on the gyro rotors. The normal operating speed of the rotors, at 3½in Hg. suction, is 15,000 r.p.m. for the artificial horizon and 18,000 r.p.m. for the directional gyro. Since the material permits mechanical working, dynamic balancing is carried out on the rotors by drilling out portions of the alloy as required. Balance of the order of 1 milligramme centimetre is obtained in this way.

High-Speed Automatic Gear Hobbing Machine

A NEW fully automatic gear hobbing machine developed and built by David Brown Machine Tools, Ltd., Sherborne Street, Manchester, and known as the "Hydrax," is designed for the rapid generation of spur and helical gears by either "climb" or conventional hobbing. This single-spindle machine has maximum hobbing speeds considerably in excess of normal requirements for single and multi-start high-speed steel hobs, and if required tungsten-carbide hobs can be used. It is capable of cutting up to 10in face width spur gears of 14in diameter with a 3in diameter hob, and up to 10in diameter gears with a 7in diameter hob. Thirty degree helical gears with a maximum face width of 3in and up to 14in diameter can be cut with a 3in diameter hob, and up to 10in diameter and 9in face width with a 7in hob. The machine takes hobs from 2½in to 7in diameter and the maximum pitch is 3 D.P. It has a fully automatic cutting cycle and a quick-acting clamping arrangement fitted to the work spindle speeds work loading and unloading.

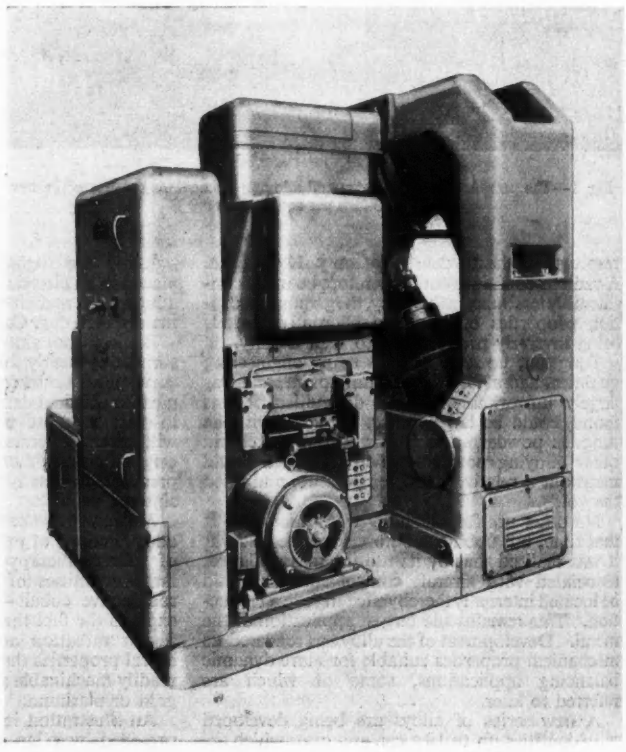
The general arrangement of the machine and its rigid, compact design can be seen from the illustrations on this page. Its construction is designed to eliminate vibration at all operating speeds. To ensure that the position of the hob relative to the work is positively maintained during cutting the column is rigidly clamped by hydraulic means to the main frame. The various machine motions can be controlled independently by hand for setting purposes, and are inoperative once the automatic cycle is set. Adjustable stops control the column infeed and hob slide traverse. Final setting of the work spindle is effected through gearing which gives angular movement of the cradle equivalent to one minute for each revolution of the dial, and a power drive can be brought into operation when any appreciable change of angle is required.

In the automatic cutting cycle once the work has been locked on its spindle, the start button is depressed and all operations are then completed in sequence. First the main and coolant pump motors start whilst the support centre is fed into the work arbor under hydraulic pressure. The column then plunge feeds the hob to depth in the work blank and is hydraulically clamped in the cutting position, while the hob feeds in a vertical direction through the work. At the end of the cutting operation the column is unclamped and quickly traverses away from the work as the motors stop and the work centre retracts. When the hob slide has then traversed rapidly back to the start position the workpiece can be changed.

The work axis is inclined to the direction of hob feed at the helix of the gear to be cut, while the hob slide is set angularly to the worm angle of the hob. When cutting the hob is traversed in a vertical direction along the helix, and by plunge feeding the hob to depth a minimum of hob traverse is required. The makers point out that a particular feature of this machine when cutting helical gears is that the first contact on the hob is some distance from the point where contact ceases—giving what is termed relative hob shift. This is automatic and is due to the contact moving along the hob as it feeds through the work. The amount of relative hob shift is dependent upon the helix angle and face width of the gear blanks to be machined. A hand-operated hob shifting arrangement enables hob wear to be uniformly distributed when cutting spur gears or helical gears of small helix angle.

The rigidly built hob slide assembly is designed to take hobs up to 7in diameter and 7in wide, and its taper roller bearing spindle is driven

High-speed automatic cycle gear hobbing machine with hydraulically operated work clamping, work spindle support centre, infeed and hob slide traverse



Hobbing machine showing electric control panel on the left and hydraulic control panel on main central column with plunge infeed stops below

through a change gearbox giving cutting speeds ranging from 80 to 600 r.p.m. In the worm gears used for the final spindle drive, the wheel is made in halves so that angular adjustments can be made to eliminate excessive backlash. As the work axis is inclined to the helix angle, it is only necessary to swivel the hob slide to the required worm angle of the hob. A minimum amount of swivel is thus required, and is made either above or below the horizontal position according to the hand of the hob. Angular readings are indicated on a vernier scale and the whole assembly gives precise setting of the hob swivel slide. The work spindle is mounted on taper roller bearings, and to minimise pitch errors in the gears to be cut the dividing worm wheel is larger in diameter than the maximum blank for which the machine is designed. Gear blanks are clamped by a strong helical spring which operates on a drawbar and is capable of producing a maximum clamping force of 15 tons. This spring is housed in the spindle and is compressed by hydraulic pressure to release the work. The hydraulic system which controls the movement of column, hob slide, rotating centre and work release is fed by a pump unit powered by a 2½ h.p. motor. The hydraulic control panel houses the control valves for column infeed, column clamping and hob slide traverse. A hydraulic workhead assembly contains valves for controlling the traverse of the rotating centre and quick release mechanism for unclamping the work. The unclamping valve is hand operated, and is electrically interlocked with the automatic cycle to prevent the machine operating with the work unclamped.

Extrusion of Stainless Steel Sections

By the collaboration of the Chesterfield Tube Company, Ltd., and Reynolds Tube Company, Ltd., considerable success has been achieved in the manufacture of extruded flash butt welded precision rings in high-grade stainless heating-resisting steels for gas turbines. It is claimed that the material when manufactured in extruded lengths from rolled billets has much better properties than cast material due to its wrought condition, that very considerable material savings accrue, and small quantities of extrusions can be made without heavy tool charges.

IT is now twenty-one years since the first plant for the extrusion of stainless steel in this country was installed at the Chesterfield Tube Company, Ltd. Techniques at that time were elementary, but tubing was successfully made varying from about 1¼in to 4in O.D. with a minimum wall thickness of 6 gauge (0·192in). Extrusion being a forging process under compression produces excellent metallurgical structures, and for this reason almost every metal and alloy can be extruded even though many of them cannot be readily forged by other methods. The greatest problems which beset this process, however, were those of lubrication and tool construction, owing to the toughness of stainless steel even at 1200 deg. to 1250 deg. Cent, and before the recent introduction of glass as a lubricant, tool wear and the problem of lubrication had rendered many applications of the process uneconomic.

This use of glass as a lubricant and insulator has made it possible to increase tool life and to reach considerably higher extrusion ratios than when using graphitic lubricants. Relatively large quantities can be applied, which at extrusion temperatures becomes viscous and forms a generous layer between the tools and the work piece. Consequently, a much wider field for extruded solid stainless sections has presented itself. At the present time the most important of these applications is the extrusion of rings for use in the manufacture of jet engines (Fig. 3).

An advantage of this process arises from the practice when extruding to have several dies in hand at a time and to use them in rotation, examining each one after it has been used. It is, therefore, quite a simple matter to change to a die of a different shape. For this reason small quantities of a product can be made without needing an expensive special tool set up, as, whatever extruded shape is required, the die cost, which is reasonably low, is roughly the same, and the life of a die is comparatively short.

Despite these considerations, the die cost is a factor which does affect the cost of extrusions. It follows that if the tolerances required were very tight an extreme case might be reached where a new die is needed for each billet extruded. If, however, more generous tolerances can be permitted, the useful life of a die will be considerably lengthened. This makes it worth while to allow for some small extra amount of machining of the completed ring.

It is invariably at the corners of a die that wear is greatest and the outside corners are normally made with a radius from 0·08in to 0·12in and re-entrant radii not less than about 0·25in. Apart from die wear it is difficult to extrude satisfactorily a very sharp outside corner as tearing of the extruded metal is very apt to occur.

Another interesting consideration which plays a significant part in extrusion costs is the balance of the section. In this way, if a long narrow fillet is associated with a thick part, such as half a dumb-bell, it would be far more satisfactory to extrude a complete dumb-bell and cut longitudinally after extrusion, so making two lengths at a time. This is referred to later as a "twin" section. The object is to avoid sharp corners, increase the cross-sectional area, the billet mass and the tons extruded per hour. Moreover, tool life is longer in the case of a balanced section. In Fig. 1 is shown a hydraulic extrusion press which the company states offers the advantage over a mechanical press of having a constant forward ram speed at any required velocity.

Fig. 3—Extruded sections for gas turbine rings

Production of Rings.—The rings are manufactured by the Reynolds Tube Company, Ltd., Hay Hall Works, Tyseley, where much of its existing machinery could be adapted for this new product.

The alloy used almost exclusively for these rings at present is the titanium stabilised, 18 per cent chromium, 8 to 12 per cent nickel type stainless steel, which for most purposes is sufficiently heat resisting to meet requirements and has good welding properties. Extrusions are, however, now being produced for special purposes in the higher chromium nickel alloys, some of which contain tungsten and also ferritic steels containing boron.

The bending of the rings is carried out in special roll bending machines using hardened and ground rolls made to embrace the section and maintain accurate limits, both on the diameter and the actual shape of the section. The rings so produced are flash butt welded on entirely automatic machines. The pre-heating cycle,

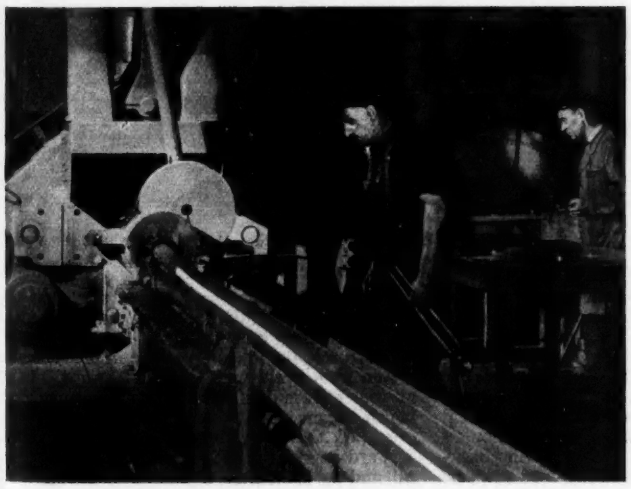


Fig. 1—Hydraulic extrusion press

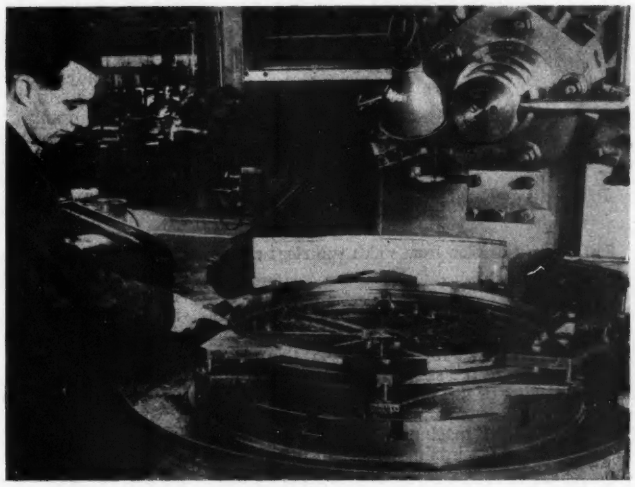


Fig. 2—Ring being machined

flashing time and upset allowance are very carefully controlled and test specimens are taken at frequent intervals for bend and tensile testing. Moreover, the stretching operation after welding, which rounds up the ring to close limits, automatically subjects each weld to a searching test. The rings are normalised from 1050 deg. Cent. at this stage, after which they are finally set by hand to a tolerance of 0·020in

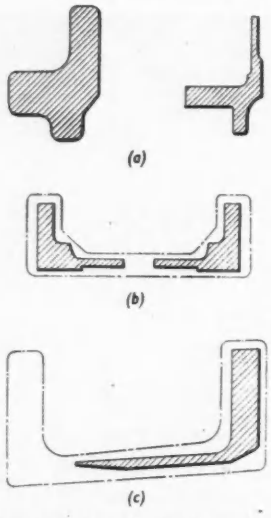


Fig. 4—Choice of extruded sections

on diameter and to a similar tolerance on flatness. Careful packing ensures that the limits are maintained after receipt at customers' works.

Design.—A complete appreciation by designers and production engineers of all limitations of the various processes, the company emphasise, is essential if the project is to be fully exploited. There are several possible variations in the design of sections which should facilitate production and reduce costs, but these must be considered in the light of plant available at the engine manufacturer's works. Much of the problem is associated with the method of clamping and locating the rings, as delivered from the manipulator's works, on to the table of the boring mill, lathe, or whatever kind of machine is being used for machining.

Given below are three specific designs of section which have been encountered to date, and there are other variations which have yet

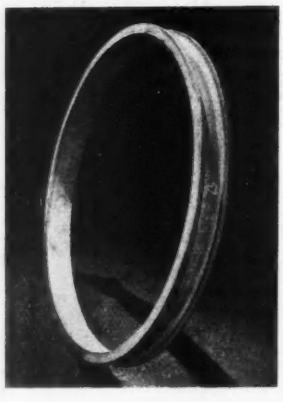


Fig. 5—An extrusion from which two rings can be cut

to be explored and which it is thought would be of benefit in specialised cases.

Method 1.—Referring to Fig. 4*a* there can be seen drawn to the same scale a profile of the finished section of the ring and that of the extrusion which has been supplied. It will be noted that the finished machined section is encased in an envelope (approximately 0·1in thick) as a machining allowance, and it has been found that this gives adequate material to ensure trouble-free machining (Fig. 2). In some cases surfaces are machined twice—that is, before and after attachment of the jet pipe.

Method 2.—Fig. 4*c* shows another approach to the problem where, by virtue of machinery available, it is felt advisable to clamp the section by a service flange, which is incorporated in the extrusion, enabling a very high proportion of machining operations to be carried out at one setting, a state of affairs which would not apply for single sections as shown in Fig. 4*a*. It can be argued that the scrap involved by the use of a service ring goes against the cost, but, on the other hand, the savings in machining time can be considerable.

Method 3.—Figs. 4*b* and 5 show yet a further development where it is considered that by extruding a double section from which two complete rings can be machined considerable economies are made over and above a single section as shown in Fig. 4*a*. It can be seen that neither extrusion nor fabrication costs would be doubled when producing a twin section and, therefore, there are savings to be derived from this when compared with Method 1.

In the illustration the finished section is shown superimposed over the double extrusion and it shows that the machining of one ring can be carried out readily when using the portion of the section allocated to the second ring for clamping purposes. There are limitations with existing plant which govern the extent to which this last method can be exploited, for example, rings having cross-sectional areas greater than $2\frac{1}{2}$ square inches cannot at the moment be flash butt welded.

Feed Attachment for Power Presses

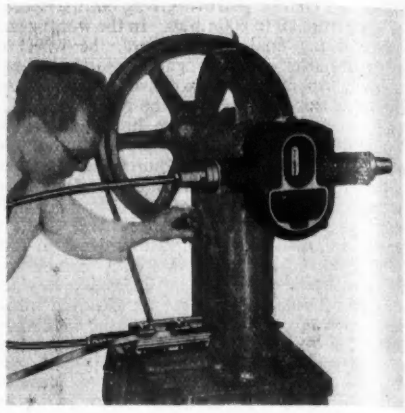
A HYDRAULICALLY operated feeding attachment for power presses made by the Birmingham Tool and Gauge Company, Ltd., Handsworth, Birmingham, is illustrated on this page. The equipment can be fitted to many types of power press, and it is designed to feed strip material in lengths up to 3in at each stroke of the machine. It accommodates strip up to $\frac{1}{4}$in thick and a reasonable width on presses with operating speeds as high as 500 strokes a minute.

One of the illustrations shows a strip feeding equipment fitted to a small power press and the other shows the two main units with their covers removed. The impellor unit is driven from the press crankshaft and is connected to the feeding slide unit by a tube which can be bent to suit the installation. In the impellor a driving disc *A* coupled to the end of the press crankshaft carries a crank pin and block which can be adjusted by means of a screw to vary the crank pin throw. The crank pin and block engage with a slide *B* cast integral with the rams *C* and *D*, so that by this means the rotary movement of the driving disc reciprocates the driving ram. A scale mounted on the outer surface of the slide facilitates adjustment of the block and crank pin when setting the feed stroke.

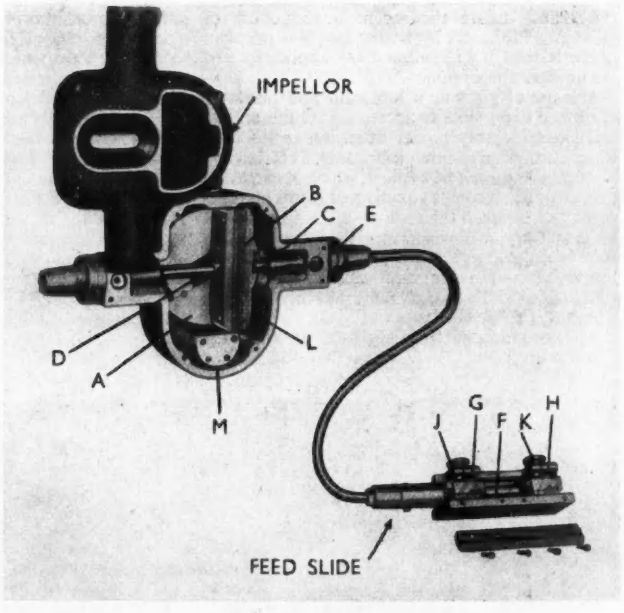
The ram *C* forms a plunger in a cylinder *E*, which opens into the tube connecting the impellor to the slide of the feed unit. This slide has a driven ram *F* and reciprocates a mechanical wedge gripper assembly in which a stationary gripper *G* prevents the stock from moving backwards, and *H* is a reciprocating feed gripper. In these grippers the clamping action is effected by rollers which bear against inverted anvils *J* and *K*. A positive gripping action is effected by the roller working on an inclined surface and locking the stock positively in one direction by wedge action. When setting the slide unit for different stock thicknesses, the stock is used as a gauge and by interposing the desired thickness beneath a shoulder on the anvils and the top surface of the gripper pads and then locking at this height, the gripper setting is automatically ensured.

In operation it is essential that the smallest movement of driving ram shall be translated powerfully and accurately to the driven ram, and for this purpose the rams are connected directly by a flexible member which runs through the bore of a tube. This tube is also filled with oil which is supplied at a low pressure through a tube *L* from a low-pressure reservoir *M*. This reservoir is automatically charged by the rotation of the driving disc and retains a quantity of fluid under low pressure for a long period when the press is not in use. This ensures that the tube is always slightly preloaded and guarantees feeding accuracy on starting up.

Because of the low oil pressure in the tube, the driven ram *F* attempts to feed forward, but is prevented from doing so by the flexible member, which becomes prestressed. In the slide feeding operation the heavy duty of carrying the stock forward is performed by a preloaded column of oil, and the comparatively light duty of returning the reciprocating gripper is effected by the flexible member.



Feed attachment driven from the crankshaft of a power press. This attachment feeds strip up to $\frac{1}{4}$in thick in lengths up to 3in at each stroke of the machine

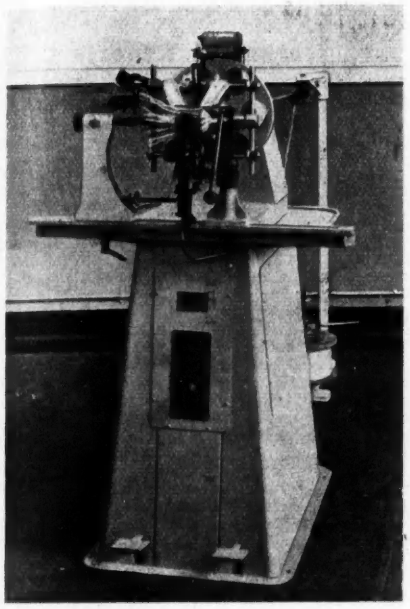


Impellor and feed slide units of press attachment with cover plates removed to show reciprocating ram drive and feed gripper arrangement

Armature Winding Machine

OUR illustration shows the No. 3 "Quickway" armature winding machine recently introduced by the Midland Dynamo Company, Ltd., 64, Belgrave Gate, Leicester. It is generally similar to the smaller "Quickway" machine and it is designed to wind conductors between 24 S.W.G. and 16 S.W.G. into slots of two-pole armatures up to 6in diameter by 6in core length.

Wire is fed from a de-reeling stand at the back of the machine, through a hollow driving shaft, to the front of the machine, where the wire is taken around a stationary armature. A looping attachment is provided for commutator lead connections and a foot-operated index device rotates the armature from one slot to the next. A second pedal operates the winding motor. The winding guides are locked and released by a single lever, which facilitates quick indexing. The armature is held between a centre at one end and a toggle clamp at the other; this quick-action clamp releases the armature for indexing or opens for its removal.



Armature winding machine suitable for winding conductors of 24 to 16 S.W.G. into slots of two-pole armatures with cores up to 6in by 6in

The unit is floor mounted and provided with a variable-speed, single-phase motor to give winding speeds up to 100 turns per minute. On the switch panel in the front of the pedestal there is a control knob whereby torque control can be provided. Above this knob is the main switch, which has three positions, "off," "forward" and "reverse."

Fixed-Frequency 1kW Radio Transmitter

A 1kW fixed-frequency radio transmitter suitable for use at airports for long-distance ground-to-air transmissions, has recently been introduced by the equipment division of Mullard Ltd., Century House, Shaftesbury Avenue, London, W.C.2. It is known as the "GFT. 560" transmitter and is said to be the first unit-built ("channelised") transmitter of this power to be produced by a British firm.

The "GFT. 560" transmitter operates on fixed frequencies in the range of 1·5 to 30 Mc/s. Multi-frequency working, using a number of different kinds of transmission—c.w., m.c.w., frequency shift, a.m., single sideband, and independent sideband, is readily achieved by using combinations of three basic units, the r.f. cabinet, the modulator cabinet, and the power supply cabinet. Any r.f. unit may be rapidly brought into circuit, facilitating the operation of channel switching. The set is fully tropicalised and is designed to run unattended; additional units are available, which permit remote control of all functions, including channel switching, over a two-wire telephone circuit. The necessary circuit adjustments are dialled to the transmitter on an ordinary telephone dial.

An advantage of the unit construction of the new Mullard transmitter is that future expansion of a basic installation may be effected simply by adding r.f. units, modulators, and perhaps power units, one of which can supply two r.f. units for simultaneous c.w. operation.

Besides being suitable for h.f. *en route* ground-to-air R/T working, the "GFT. 560" set may be employed in point-to-point circuits in radio-telephone networks, where its ability to handle single-sideband and independent sideband signals is significant. A choice of modulator units provides audio-frequency responses of communications or broadcast quality.

Echo-Sounding Recorder

AN echo-sounding recorder, which has been designed primarily as a marine navigational aid but is also capable of detecting shoals of fish beneath a ship, is being manufactured by the Marconi International Marine Communication Company, Ltd., Chelmsford, Essex.

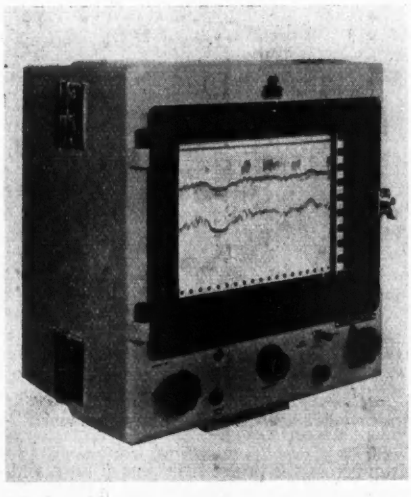
The instrument is known as the "Graphette." It operates in conjunction with one or more signal projectors but, apart from these projectors, the complete installation is contained in a single casing as illustrated herewith. In this instrument the record of depth is made by a stylus which moves in a straight, vertical line over a dry sensitised paper, which travels horizontally from a roller across the front of the instrument onto a second roller. The viewing window of the recorder frames a 10in length of recorded soundings, which is equivalent to about twenty-five minutes of steaming time. Each 100ft roll of paper allows for 50 hours of operation.

Depths are indicated by vertical displacement of the stylus trace and the paper is calibrated in 1 fathom intervals. The paper also carries vertical time lines, 2in apart, each interval representing five minutes of steaming time.

Depths up to 140 fathoms are covered by the "Graphette" instrument in two phased ranges of 0 to 80 fathoms and 60 to 140 fathoms. The phasing system provides facility for discrimination and the 20 fathom overlap between the two ranges obviates the need for frequent range changing when the ship is steaming over depths varying slightly above or below 80 fathoms.

The instrument case is of cast alloy and is approximately 16in wide, 17in high, and 10in deep, being designed for bulkhead mounting. The front panel is hinged and opens to give access to the recording mechanism and the transmitter and receiver chassis, which is also hinged so that all components are easily reached for servicing. The "Graphette" can be operated with one projector, but the maker recommends double projector working for optimum results in fish indication. The instrument is designed to operate from a battery power supply of 24V, but a rotary transformer can be supplied for operation from ships' mains if preferred. The total power consumption is approximately 35W and the transmitting circuit is designed to provide ample power at the projector for giving clear indications of fish shoals.

A "stand-by" position incorporated in the main switch enables the "Graphette" to be kept in readiness for instant use while fishing so that soundings show within three seconds of changing from "stand-by" to "on." When switched directly from "off" to "on" there is a warming-up period of approximately thirty seconds before soundings begin. Other controls are for sensitivity, scale brilliance and range selection, while provision is made for draught adjustment and for marking a vertical line across the paper to separate one series of recordings from the next.



"Graphette" echo-sounding recorder. Soundings and indications of fish shoals are recorded by a stylus on dry sensitised paper

Front Wheel Drive Bulk Loader

OUR illustration shows a bulk loader having a front wheel drive and a bucket capacity of 2500 lb, which has been introduced by Mathews Brothers, Sandy Lane North, Wallington, Surrey. As with the company's front wheel drive fork-lift truck, which was described in THE ENGINEER, December 19, 1952, the vehicle is fitted with either the diesel or petrol Fordson "Major" engine, developing 40 h.p. at 1650 r.p.m. The gearbox provides six forward and two reverse speeds and the maximum road speed is 20 m.p.h.

Loader with the bucket tipped and arm extended

The loader has been designed with particular attention to the need for a machine capable of handling all kinds of heavy and awkward loose bulk under adverse conditions. The disposition of the load over the front drive wheels is claimed to provide certain advantages. Amongst these is the ability of the scoop to bite more deeply into a load and improved side stability and traction when digging, especially when negotiating soft ground. It is fitted with six-ply air pressure tyres, 14in by 30in (56in O.D.) on single driving wheels. The steering wheels are 39in in outside diameter and the outside turning radius, using steering brakes is 116in. Another advantage claimed for the machine is its relatively high ground clearance of 16in and its ability to traverse rough unmade gradients and deep thick mud with a full load were convincingly shown at a recent demonstration of the vehicle.

Control of the bucket and arms is hydraulic in all positions, the bucket being fully compensated by a parallel linkage. The lift and

bucket tilt time is eight seconds and two seconds respectively, the bucket having inching controls to enable the machine to handle and pour liquid loads. Under the tipped bucket the maximum lift height is 120in (150in over hoppers), and outreach with the bucket level is 72in. The standard bucket capacity is 1 cubic yard, and the machine can be provided with other bucket capacities or, interchangeable with the bucket, it can be fitted with forks, crane or dozer blade.

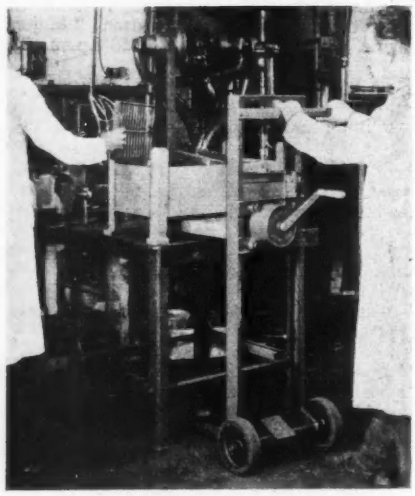
The driving and hydraulic controls are all grouped within the cab, which is particularly well sighted and completely enclosed by a single hinged canopy.

The vehicle weighs 4 tons 10 cwt and is 189in long overall, 77in wide with an overall height of 101in.

Light-Duty Hand-Operated Fork Truck

WE illustrate below a new piece of mechanical handling equipment, known as the "Translifter," now being made by Barron and Shepherd, Ltd., 24, Buckingham Street, London, W.C.2. This piece of equipment is designed as a small manually operated and propelled fork-lift truck for light duties in restricted places, where power-driven machines could not economically be used.

The "Translifter," as can be seen, consists essentially of a fabricated steel frame mounted



Hand-operated fork truck being withdrawn after elevating pallet and depositing it on to a work bench

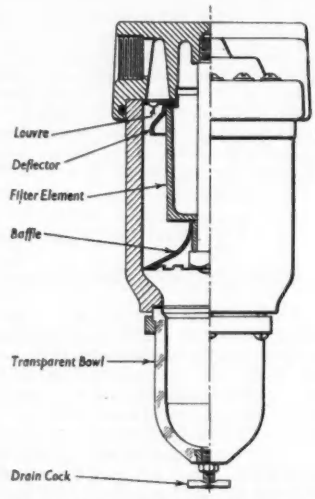
on two wheels and a front support wheel. It has a pair of load supporting forks, which are raised and lowered by means of a self-sustaining hand winch. The truck is used in a similar manner to a sack barrow to carry a small pallet to a work bench or machine, where the load can be raised to the required level. With the pallet thus elevated the truck is pushed forward and the load lowered on to the bench.

These trucks are made in 1-cwt and 5-cwt capacities with a normal lift of 3ft 6in from the lower fork position of 3½in above ground level.

Compressed Air Filters

Two new sizes of transparent bowl compressed air filters have been introduced to extend the capacity range of the units made by C. A. Norgren, Ltd., of Shipston-on-Stour, Warwickshire. The smallest of these filters is for ¼in and ⅜in pipe sizes and air flows up to 30 cubic feet per minute. The larger filter, for ¾in and 1in pipes, can be used for air flows up to 140 cubic feet per minute. Both filters are suitable for air pressures of up to 150 lb per square inch, at temperatures from 40 deg. to 120 deg. Fah. In these filters the moisture collects in the transparent bowl so that the condition of the air line and the need to drain the bowl can readily be seen.

The design of the larger filter, which is generally similar to the small filter, can be seen in the diagram below. In this filter the air enters the body and passes into an annular groove on the underside of the body. The groove, which is of suitable size to allow unrestricted air flow, is covered by a brass plate in which louvres are punched. Air passing through these louvres is directed in a swirling motion round the inside of the filter bowl. Centrifugal force serves to throw



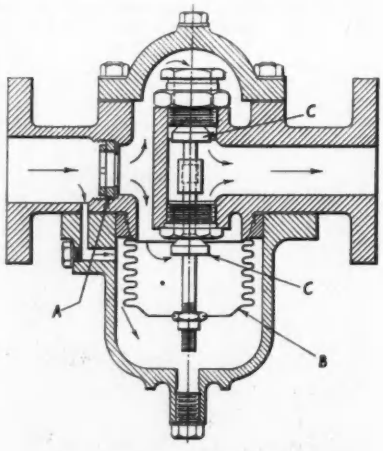
Arrangement of transparent bowl compressed air filter

out the particles of dirt and free moisture which drain down to the base of the filter. The deflector ensures that all air is subjected to the swirling action and the baffle plate prevents water and dirt, once separated, being picked up again by the air stream. The air then passes inwards through a sintered bronze filtering element and on to the outlet. On both filters the sintered bronze filter element is such as to filter out particles greater than 40 micron in size.

Flow Controller

THE mechanism of a new flow control instrument, known as the "Flostat," now made by Ultrasonics, Ltd., Westgate, Otley, Yorks, is shown in the drawing we reproduce below. It is made in three sizes to control flows ranging from less than 10 gallons to 3000 gallons an hour and is designed to maintain a constant flow irrespective of liquid pressure variations.

An orifice plate *A* is positioned in the housing on the feed side of the controller and the pressure



Mechanism of instrument for controlling flow at predetermined levels independent of pressure variations

drop across the orifice is by-passed on the high pressure side to a bellows *B* sealed in the housing. On the low pressure side the flow continues through the double beat valve *C* connected to the bellows. Fluid from the feed line in front of the orifice plate is by-passed into the bellows chamber. In operation the pressure difference between the outside and the inside of the bellows causes it to move to a position of equilibrium. Since the bellows is connected to the stem of the valve on which there is no pressure loading, the valve is opened or closed depending on whether there is an increase or decrease in the upstream flow. In this way the valve setting is automatically adjusted to maintain the flow of liquid constant irrespective of pressure changes.

The makers state that this instrument maintains an accuracy of plus or minus 1 per cent and it recovers settings within a few seconds of flow change. If required the component parts can be made of suitable materials for handling corrosive liquids.

Technical Reports

Symposium on "Utilisation of Radiation from Fission Products" (Harwell, February 23 and 24, 1953). Edited by G. N. Walton and J. Wright, Atomic Energy Research Establishment, Chemistry Division. H.M. Stationery Office. Price 20s.—This report consists of an introduction to the symposium, by R. Spence; use of the gamma radiation from reactor fuel rods, by W. Wild and J. Wright; use of the radiation from fission product wastes, by C. B. Amphlett; the specific activity of separated fission products from reactor fuels, by G. N. Walton; the separation of long-lived fission products, by P. E. Carter; technical feasibility of the use of fission products, by M. W. Perrin and L. Seed; economic feasibility of the use of fission products, by J. W. Barrett, B. L. Budd, B. Roberts and D. S. P. Roebuck; preservation of food, by R. S. Hannan; sterilisation of pharmaceutical products, by W. Jones; high energy radiation and long chain polymers, by A. Charlesby; the effects of ionising radiation on organic high polymers, by K. Little; introductory talk on the uses of radiation in medicine, by W. V. Mayneord; methods of mounting separated fission products safely for industrial and medical use, by W. P. Grove; Caesium 137 and its use, by W. S. Eastwood; bibliography of fission product utilisation covering the period 1945 to April, 1953, by O. T. Davidge.

This report is a declassified account of the meetings and includes the papers presented together with an account of the discussion which took place.

Radio Interference from Motor Vehicles, Comparison of British and German Measuring Equipment (Ref. M/T123). By A. H. Ball, A.M.I.E.E., and S. F. Pearce, B.Sc., A.Inst.P. The British Electrical and Allied Industries Research Association, Dorking Road, Leatherhead, Surrey. Price 10s. 6d.—Interference from the ignition systems of motor vehicles has become more pronounced in Germany since the inception of a television service. The anticipated rapid expansion of this service has prompted the authorities (F.T.Z.) to consider the introduction of regulations for the control of this form of interference. Measurements made in Germany using equipment built by Messrs. Rohde and Schwarz for the F.T.Z. have been compared with data obtained in Great Britain using the Post Office Measuring Set "R12." Difficulties have been experienced both in Germany and in Great Britain in correlating the data obtained in the two countries. Tests were therefore arranged through the offices of Joseph Lucas, Ltd., and the E.R.A. in Great Britain and the Bosch Company and the F.T.Z. in Germany to compare the behaviour of the British and German measuring equipment. This report summarises the results of tests carried out in January, 1953, at the F.T.Z., Darmstadt, and indicates the reasons for the differences in indication of the two equipments when measuring the field radiated from the ignition system of a motor vehicle.

Intrinsically Safe Electrical Apparatus: Relation of Igniting Current to Circuit Inductance for Inflammable Mixtures of Calor Gas (Butane) and of Cyclohexene with Air (Ref. G/T282). By E. M. Guenault, M.Sc., Ph.D., E. Atherton and F. Shaw. The British Electrical and Allied Industries Research Association, Dorking Road, Leatherhead, Surrey. Price 6s.—This report covers the determination of the range of mixtures of calor gas (butane) and of cyclohexene, with air, which are most readily ignited by the type of sparks produced when an inductive circuit is rapidly broken. The relation of igniting currents to circuit inductance for such mixtures has been established. The results show that the ignitability of these mixtures does not differ appreciably from that of the most readily ignitable mixture of pentane and air. The investigation was made at the S.M.R. Establishment of the Ministry of Fuel and Power at Sheffield.

Industrial and Labour Notes

Overseas Trade

The Board of Trade has now published its final figures on the United Kingdom's overseas trade in April. The value of exports was £224,900,000, a figure which was £500,000 above the monthly average in the first quarter, despite the fact that there were only twenty-four working days in April. The average value of exports in the first four months of this year was 7 per cent above that for the corresponding period of last year.

In the second quarter of the year, the Board of Trade says, there is usually an increase in the value of imports with heavy arrivals of commodities from sterling countries in the Southern Hemisphere. In April, however, this expected increase was limited in amount, and the total value of imports, at £284,300,000, was less than the March total and only £10,500,000 above the average in the first quarter. Over the first four months of the year, imports were at a rate of £276 million a month, or £1,000,000 a month lower than in the comparable period of 1953. On this matter, the Board of Trade's comment is that "there would have been a significant increase but for a fall in prices in the past year." There is, however, some evidence that the decline in import prices, which has continued for over two years, is now coming to an end. Re-exports, the value of which increased sharply in March, fell back to £8,000,000 in April. The excess of imports over total exports thus amounted to £51,300,000 in April. For the first four months of the year, the trade deficit amounted to £42,600,000 a month, compared with £57,600,000 in the corresponding period of last year.

About the commodity pattern of trade, the Board of Trade says that, although the total value of United Kingdom exports in April was little different from the monthly average for the first quarter, there was a rise of over £1,500,000 in the value of exports of metals ; the total in April, over £29,000,000, was only a little below the high monthly rate recorded in the last quarter of 1953. Exports of engineering products in April, valued at £87,000,000, were at about the same level as in the first quarter and maintained the improvement shown during 1953. There were the usual seasonal increases in exports of road vehicles to Europe and North America ; Sweden and Canada took more motor-cars and there were bigger shipments of cycles to the U.S.A. Exports of cars and chassis to Australia increased, and more agricultural and track-laying tractors were exported to Europe. On the other hand, there was a reduction during April in exports of electrical generators and motors, and electric cables. Aircraft and ships also showed reductions of more than £500,000 each in April, compared with the first quarter's average.

Industrial Investment

A statement concerning industrial investment is included in the latest issue of *Bulletin for Industry*, a monthly review of the economic situation prepared by the Treasury. It says that at various times in the last five years, investment in the United Kingdom has been limited by steel shortages, by the defence programme and by the need to increase engineering exports. In 1951 and 1952 the Government discouraged investment because the claims of exports and the defence programme had to have priority. Last year, with steel output high and allocation removed, with freer licensing of new factories, and with more capacity available in the capital goods trades, it was possible for investment to rise again, and, the *Bulletin* comments, initial allowances were restored in the 1953 Budget to encourage it to do so. Total investment, it is stated, after remaining more or less stable in 1951 and 1952, rose by about 10 per cent in 1953, and, at current market prices, is estimated to have totalled £2312 million. Last year, there were increases in investment in new housing and in the basic industries. Investment in manufacturing industry, however, remained stable in 1953, and, allowing for price changes, there was probably a slight fall in the volume of investment.

The *Bulletin* goes on to say that one of the main factors determining this country's standard of living is the amount of its productive resources, and that in turn depends on how much industry invests each year to replace, extend and modernise those resources. An adequate level of industrial investment is essential to enable this country to take advantage of the expanding world market. The *Bulletin* adds that more investment is needed to increase capacity to produce those goods for which demand abroad is strong, and also to improve existing capacity in ways which will raise productivity and reduce costs. Our ability to compete in world markets, the *Bulletin* says, depends upon the use that is made of modern machinery and the rapid application of the results of research and scientific discovery. There has been little change in productive investment in this country over the past few years, the *Bulletin* comments, but investment in the U.S.A., in Germany, and in some other European countries has continued to rise.

National Coal Board's Report

At the end of last week, the National Coal Board published its eighth annual report, which records the coal industry's activities during 1953. The report says that last year's output of deep-mined coal was 212,500,000 tons, which was about 1,800,000 tons below the 1952 total. The five-day week output was lower last year, but there was more voluntary working on Saturdays. Last year's coal production from opencast workings, at 11,700,000 tons, was below the 1952 figure. Although the total number of men employed fell during last year from 721,000 to 710,000, the Board says that the average number of men working at the face was, at 300,000, higher than in any year since the war.

The section of the report which deals with manpower says that in some of the Board's divisions restrictions were placed on adult recruitment because pits were manned to capacity. Other divisions, however, which needed more men, could not get enough. Throughout the year, the Board continued to recruit as many boys as possible, and actually took on more than in any year since nationalisation, apart from 1952. Improvements were made in training facilities and, by the end of the year, the new residential training centre at Alloa was nearly ready for opening. Last year, the amount of deep-mined coal estimated to have been lost through trade disputes was 1,150,000 tons. Although this was 560,000 tons less than in 1952, the report says that the number of stoppages and restrictions (2324) was much the same, the reason for less tonnage lost being that there were no major disputes during the year. The losses were again heaviest in the Scottish, North-Eastern and South-Western Divisions, three divisions which have accounted for over 80 per cent of the tonnage lost by disputes in the last three years. Reference is made in the report to the agreement of the National Union of Mineworkers to join with the Board in an efficiency campaign. Although the results are difficult to assess, the report comments, the campaign certainly helped to achieve the increase in Saturday working. The hope is expressed in the report that "the campaign will be continued and result in further improvements in 1954." Average productivity at the coal face in 1953 was 3·14 tons a manshift, which was 0·01 ton lower than in 1952. Overall productivity, however, at 1·21 tons a manshift, was slightly higher than in 1952.

Dealing with the financial results, the report shows that, after deducting interest and interim income payable to the Minister of Fuel and Power, there was a surplus on the year's working of £353,647, compared with a deficit in 1952 of £8,200,000. Last year's surplus meant that the accumulated deficit since vesting day was reduced to £13,600,000. The Board spent £64,300,000 on capital account in 1953, compared with £48,600,000 in 1952. It is stated in the report that, of the increase, about £1,000,000 was attributable to higher prices ; £52,400,000 was spent on collieries, £4,900,000 on coke ovens, and £7,000,000 on other activities, including opencast working. Last year, the costs of producing coal rose by 2s. 6d. a ton, the cost of wages rose by 11s. 1d. a ton, and holiday pay cost 2s. 3d. a ton more. The average earnings of face workers last year were £12 18s. 3d. a week in cash, the value of allowances in kind being 10s. 5d. The cash earnings of surface workers were £8 13s. 10d. a week, the value of their allowances in kind being 9s. 9d. a week.

Professional Civil Servants

The annual conference of the Institution of Professional Civil Servants opened in London last Monday morning with an address by the president, Sir Richard Redmayne. Sir Richard said that, in his view, the Civil Service must be composed of officers of the first quality or, inevitably, it must fail in its duty. The country looked not only to the integrity of the Civil Service, but also to its intellectual quality, yet, Sir Richard observed, the Treasury deliberately set out to find the generality instead of the first class.

Sir Richard went on to say that when the Treasury set its aim low, its performance would inevitably be even lower. Referring in particular to the Mines Inspectorate, of which he was at one time head, Sir Richard remarked that of a total complement of only 149 there was a shortage of thirty-six officers. Efforts at recruitment, he said, failed completely, and the reason was a simple one, for the Civil Service offered to inspectors of mines a salary which was less than that already received by the people from whom it was essential that the recruits should be obtained. The same, Sir Richard added, could unhappily be repeated about other parts of the professional Civil Service, such as the Factory Inspectorate and the Royal Corps of Naval Constructors. A "similar sorry story," he said, could be told of the technical classes.

Stability in the Engineering Industry

Some comments on the need for stability in the engineering industry are made by Sir Alexander Roger, chairman of Automatic Telephone and Electric Company, Ltd., in a statement circulated with the annual report. Sir Alexander says that not only in the engineering industry, but also in the country generally, there is a "most critical stage" concerning wage increase claims. Since the end of the war, his statement continues, there have been almost perennial claims by the unions for higher wages. So long as the inflationary price spiral continued to soar unchecked these claims were to some extent justified, and an appropriate increase was settled. But, Sir Alexander observes, the fact that the inflationary trend has been halted has not put a stop to wage demands, and, although a fresh settlement was made in the engineering industry a month or so ago, it is disturbing that the unions have given no assurance that they will not seek further increases during 1954.

Sir Alexander goes on to emphasise the need, at this stage in the export trade position, for a period of stability, in which efforts to reduce production costs are not nullified by incesssant wage claims. Many of the wiser union leaders, he says, realise that such demands, if granted, will only induce further inflation. There are others who believe that to keep their jobs there must always be a wage claim pending. In the past, the statement goes on, it has to some extent been possible to pass on to the customer the increased costs resulting from higher wage rates, but there is ample evidence now that a situation has been reached where higher prices will mean loss of business in the export markets.

Industry, Sir Alexander says in his statement, can only meet increased costs by higher productivity and greater efficiency. The means must be examined of introducing incentive schemes designed to produce the necessary extra effort.

Notes and Memoranda

Air and Water

ASIAN WATER RESOURCES CONFERENCE.—Last week there was held in Tokyo an Asian water resources conference, which was arranged by the United Nations Economic Commission for Asia and the Far East. The subjects discussed included the control and utilisation of Asia's water resources for irrigation, navigation, water power development and flood control, and the conservation and protection of soil from erosion. In connection with the conference, there were three " study tours " of dams and multiple-purpose projects in Japan.

Miscellanea

DEMONSTRATION VAN FOR ELECTRIC TOOLS.—A van has been fitted up as a travelling showroom by B. Elliott and Co., Ltd., Victoria Works, Willesden, London, N.W.10, to demonstrate its " Selecta " range of electric tools, which includes grinders, drills, nibbling shears, &c.

BRITISH JOINT SERVICES MISSION.—The Ministry of Supply announces that Air Commodore L. R. S. Freestone has been appointed to succeed Air Commodore C. L. Dann as Director (Air) of Technical Services, British Joint Services Mission, Washington, U.S.A. Air Commodore Freestone held the post of Director of Armament Engineering in the Air Ministry since November, 1952.

" WYNN " DIAPHRAGM VALVES.—Charles Winn and Co., Ltd., has now acquired all rights in the " Wynn " straight-through diaphragm valve and a subsidiary company has been formed to develop the sale of the valves. The valves are being manufactured by the parent company at Granville Street, Birmingham, and additional manufacturing space has been provided close to the main works for future expansion.

OBITUARY.—We record with regret the death of Mr. H. W. Pearn, which occurred suddenly on May 5th. Mr. Pearn, who was seventy-seven, was for many years chairman and managing director of Frank Pearn and Co., Ltd., Manchester. We regret to record also the death, at the Middlesex Hospital, London, on May 20th, of Mr. Benjamin Henry Hovey, managing director of Soag Machine Tools, Ltd.

E.I.A. DIRECTORY.—The Engineering Industries Association has published, in collaboration with the Standard Catalogue Company, Ltd., the fifth edition of its classified directory. The directory includes a complete list of the names and addresses of the Association's member-firms, and gives brief notes about their manufactures. The list is followed by a buyers' guide section in which the firms' products are classified under more than 5000 headings.

SEARCH FOR NATURAL GAS.—Deep drilling for natural gas in Sussex, as part of the Gas Council's five-year exploration plan, is due to start shortly, near Crowborough Warren, Crowborough, in the vicinity of Ashdown Forest. It is expected that the well will be drilled to a depth of about 2000ft, and that the work will take between three and four months. The work is being carried out on behalf of the Council by the D'Arcy Exploration Company.

ROYAL SOCIETY RUTHERFORD MEMORIAL APPOINTMENTS.—Under the terms of the scheme to commemorate the late Lord Rutherford of Nelson the appointments have been announced by the Royal Society. The council of the society has appointed Dr. E. Marsden, of New Zealand, as the Rutherford Memorial Lecturer for 1954, and Mr. D. M. Brink, a graduate of the University of Tasmania, as a Rutherford Scholar for three years from October 1, 1954, to carry out research in nuclear physics at the Clarendon Laboratory, Oxford.

EUROPEAN CHEMICAL ENGINEERING CONGRESS.—The Congress of the European Federation for Chemical Engineering for 1955 will take place in Frankfurt a. Main from May 14 to 21, 1955, on the occasion of the Chemical Apparatus and Equipment Exhibition and Congress. At the congress there will be nineteen technical and scientific societies from eleven countries that form the European Federation for Chemical Engineering. The preparatory work in connection with the congress is being undertaken by the DECHEMA Deutsche Gesellschaft für Chemisches Apparatewesen, Frankfurt a. Main, 13. The latest and most important scientific discoveries and technical developments in the chemical engineering field will be described in a series of about eighteen plenary lectures. In addition to this series, it is also intended that a number of lectures on special subjects in the same fields will be delivered. The programme of the congress will be supplemented by a number of works visits and social functions.

INDUSTRIAL DELEGATION TO BURMA.—The report of the industrial delegation which visited Burma, under the leadership of Lord Burghley, in March, has been published this week by H.M. Stationery Office, price 2s. 6d. The report describes the Burmese Government's development programme which includes public works and industrial projects. It draws attention to the great opportunities for United Kingdom consultants, contractors and manufacturers of plant and equipment to contribute to the programme. Special emphasis is given to the necessity to quote firm prices and quick delivery dates, and to offer training facilities for Burmese maintenance staff and operators.

SPHEROIDAL GRAPHITE CAST IRON.—In order to demonstrate the properties and some of the many applications of spheroidal cast iron an exhibition was held this week by the Mond Nickel Company, Ltd., at Park Lane House, London, W.1. This material, which can be readily cast into complex shapes with a wide range of section thickness, is rigid, has a high yield point and is considerably stronger than good quality grey cast iron. These and other properties of the metal were shown in demonstrations and by means of diagrams at the exhibition. Full details of the qualities and industrial applications of spheroidal cast iron are also given in booklets obtainable from the offices of the Mond Nickel Company, Ltd., 45, Park Lane, London, W.1.

INDUSTRIAL DESIGN EXHIBITION.—An exhibition entitled " Designed and Manufactured . . ." is to be held at the L.C.C. Central School of Arts and Crafts, Southampton Row, London, W.C.1, from June 22nd to 25th. The display will have two themes—an illustrated story of a product through all its stages of design, planning, tooling and manufacture, and the story of students in training for posts as designers in industry. Whilst illustrating the work which is entailed in the transformation of an idea for any article of every-day use into reality, the exhibition will also demonstrate a method by which prospective industrial designers are taught how to create products which are not only good to look at, but which are also efficient and easy to mass produce.

FLOOR LEVEL CHARGING OVEN.—A new electric oven made to stand on a heat-insulated floor for charging at floor level has been designed by the General Electric Company, Ltd. The design greatly facilitates the use of bogies which can be moved directly into the oven, and by using two or more bogies the oven can be kept in continuous operation. To minimise heat losses through the walls the oven has a double-cased construction, the space between inner and outer casing being packed with a high-grade refractory. Tubular heating elements are arranged in the oven walls behind baffles, and a fan in the roof provides vertical forced air circulation down over the elements and up through the oven. The oven can be supplied in a wide range of sizes to operate at temperatures up to 250 deg. Cent.

O.E.E.C. AND STANDARDISATION.—The important part which standardisation plays in raising productivity is stressed in a new recommendation by the Council of the Organisation for European Economic Co-operation, urging member Governments to increase the assistance already given to national non-governmental bodies responsible for the preparation of standards. Governments are also recommended to encourage the use of products conforming to the standards established by these bodies by all possible means. Three possibilities of such action are suggested. The first is to provide for the use of standardised products in contracts placed or controlled by governments. The second is to encourage the use of standards in private industry and commerce, and finally, it is suggested that governments should refer to these standards in the drafting of laws, decrees or regulations.

INSTITUTION OF GAS ENGINEERS.—The ninety-first annual general meeting of the Institution of Gas Engineers is to be held from Monday to Thursday of next week, May 31st to June 3rd, at Bournemouth. Mr. J. T. Haynes will deliver his presidential address, in the Winter Gardens, on Monday morning, following a civic welcome at 9.30 a.m. At subsequent sessions in the morning of each day of the meeting, the following papers will be presented for discussion : " The Organisation of the Gas Industry in the South West," by Mr. C. H. Chester ; " Civil Defence and the Gas Industry," by Mr. W. N. Marshall ; " Natural Gas and the Italian Gas Industry," by Dott. Ing. A. Böhm ; " Centralised Control of a Gas Grid," by Mr. F. G. Symon ; " The Appreciation of Factors Affecting Cost in the Gas Industry," by Dr. J. M. S. Risk, and " Human Relations in the Gas Industry," by Mr. Henry Lesser.

DURHAM BURSARY.—The Junior Institution of Engineers announces that it offers, for annual competition, the Durham Bursary of the value of £20 in cash. The award carries with it membership of the Institution for three years. Candidates must be over nineteen and under twenty-five years of age at the time of entry, but they need not already be members of the Institution. They must be young men born of British parents in the British Isles, New Zealand, Australia, Canada or South Africa. They must be in course of training for the engineering or an allied profession by employment in a technical office or works, or by attendance at a recognised university, college or institute. Entrants compete by submitting a thesis written in English on some engineering, technical or scientific subject selected by themselves, such thesis being written specially for the bursary award. Further particulars may be obtained from the Junior Institution of Engineers, 39, Victoria Street, London, S.W.1.

" EUROPEAN CO-OPERATION IN NUCLEAR RESEARCH."—A booklet has been published by the United Nations Educational Scientific and Cultural Organisation describing the progress of European co-operation in nuclear research. The European Council for Nuclear Research was set up in 1952 ; it was known as CERN and eleven countries were represented on it—Belgium, Denmark, France, German Federal Republic, Greece, Italy, Netherlands, Norway, Sweden, Switzerland and Yugoslavia. The United Kingdom did not become a formal member of the organisation, but it has taken an active part in its work and has given financial support. Its task was to organise collaboration in the study of phenomena involving high-energy particles, and it had to plan the establishment of an international nuclear laboratory. This task was completed in fourteen months, and CERN will shortly be replaced by a permanent organisation, according to a convention signed in July, 1953, by the twelve members who have taken part in the work of CERN. The booklet outlining the history of this organisation is entitled " European Co-operation in Nuclear Research," and is obtainable from Her Majesty's Stationery Office, price 1s.

ALUMINIUM BRAZING AND WELDING FLUXES.—Two new fluxes and a solder for use with aluminium are now being supplied by Plus-Gas Company, Ltd., 1–11, Hay Hill, London, W.1. The first of these fluxes—" Green Uniflux "—is suitable for brazing aluminium and aluminium alloys containing up to 2·75 per cent magnesium, to weldable stainless steels using pure aluminium or 5 per cent silicon rods. The second flux—" Red Uniflux 10X "—is a non-corrosive aluminium welding and brazing flux. It can be used for welding aluminium and aluminium alloys containing up to 10 per cent magnesium ; brazing aluminium and aluminium alloys containing up to 5·5 per cent magnesium, and for welding electron and magnesium base alloys containing over 10 per cent magnesium. The new solder is used for preparing aluminium and aluminium base alloys by depositing a basic coat of metal after which similar or other metals can be soldered on to the treated area with the use of tinman's solder or plumber's metal.

BRITISH GEAR MANUFACTURERS' ASSOCIATION.—The tenth annual general meeting of the British Gear Manufacturers' Association was held in London on Tuesday last, May 25th. At this meeting a paper entitled " Ball and Roller Bearings : A Practical Review of Applications, &c.," was presented by Mr. F. O. Hickling. At a luncheon which followed the meeting the toast of the institution was proposed by Dr. F. T. Barwell, who dealt with some of the common problems of gear and bearing design and lubrication. Responding to the toast, Mr. J. E. Skidmore, the chairman of the Association, said that it was steadily growing and now had forty-three member and associate firms. In responding to the toast of " The Guests," proposed by Mr. E. B. Wilson, Captain J. O. H. Gairdner, R.N., spoke at some length on the problems of gear design and manufacture in connection with modern gunnery control apparatus. He said that the degree of accuracy now called for was such that it had been necessary to develop a new range of gear standards with tolerances far closer than had hitherto been considered possible. In this work the Admiralty technicians were receiving the full support of the industry, although far more work had yet to be done on the development of suitable manufacturing plant and measuring equipment.

Contracts

RICHARD C. GIBBINS, Ltd., Berkley Street, Birmingham, has received an order for seven electric overhead travelling cranes from Shell-Mex and B.P., Ltd., for use in the engineering workshops at the Stanlow refinery.

MARCONI'S WIRELESS TELEGRAPH COMPANY, Ltd., Chelmsford, has received a contract from the British Broadcasting Corporation for a further fourteen " V.H.F." frequency-modulated transmitters, together with associated equipment.

Personal and Business

MR. D. L. POLLOCK has joined the board of Vickers, Ltd.

SIR GEORGE BRIGGS, a director of Tube Investments, Ltd., has joined the board of the Brush Group, Ltd.

MR. W. H. CARTWRIGHT has been appointed general manager of Stern and Bell, Ltd., Warstock Road, Birmingham.

THE BOARD OF TRADE states that Mr. R. L. Walsh, Master Cutler, has been appointed a member of the Council of Industrial Design.

CLARKSON (ENGINEERS), Ltd., Nuneaton, has opened a branch office and stockroom at 430, Crown Street, Glasgow (telephone, South 1942).

THE ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS has changed its address to 23, Bloomsbury Square, London, W.C.1 (telephone, Langham 5927).

MR. R. M. W. GRANT, M.I.E.E., has been appointed manager of the transformer works of the General Electric Company, Ltd., Witton, in succession to the late Mr. C. H. Nunn.

DUNLOP RUBBER COMPANY, Ltd., announces the retirement of Mr. Charles Sinclair, sales staff executive at the London headquarters, after forty-three years in the company's service.

THE QUASI-ARC COMPANY, Ltd., Bilston, Staffs, announces that, as from June 1st, it becomes the licensee in Great Britain and the Commonwealth (excluding Canada) for the " Sigma " metallic arc welding process.

THE MINISTRY OF SUPPLY states that Colonel G. Kellett has succeeded Brigadier W. G. Abinett as director of inspection of armaments. Colonel Kellett has been deputy director of artillery in the Ministry since June, 1952.

BRITISH INSULATED CALLENDER'S CABLES, Ltd., states that Mr. W. H. McFadzean, deputy chairman and chief executive, will succeed to the chairmanship of the company on June 10th, following the retirement of Sir Alexander Roger.

THE BRUSH GROUP announces that the parent company will in future be known as the Brush Group Ltd. The name Brush Electrical Engineering Company, Ltd., has been given to the group's subsidiary company managing the factory at Loughborough.

B.S.A. TOOLS, Ltd., announces the formation of a new company entitled Precision Alloy Castings (Birmingham), Ltd., for the development and manufacture of precision alloy steel castings. Mr. H. J. Moyser is chairman of the new company and Mr. H. P. Potts is the managing director. The headquarters of the company are at Mackadown Lane, Kitts Green, Birmingham, 33 (telephone, Stechford 3071).

British Patent Specifications

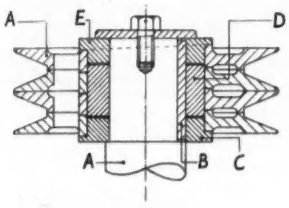
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 8d. each.

POWER TRANSMISSION

708,433. February 27, 1951.—PULLEYS FOR VEE OR ROUND BELTS OR ROPES, John Edward Cumming, "Ballaggan," Heath Lane, Stourbridge, Worcestershire.

The drawing gives a section of a pulley according to the invention. This pulley is machined and assembled from similar cast metal discs *A*. Its shaft has a reduced

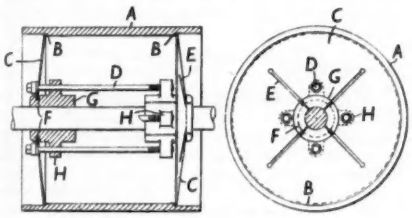


No. 708,433

portion upon which a key *B* is fitted to retain and align sleeves *C*, *D* and *E* which are a light press fit on the shaft. The flanged end face of sleeve *C* abuts against the shoulder face of the shaft to prevent endwise movement. Discs *A* form a rope drive and are assembled by a light push fit on the sleeves, as shown. Sleeve *E*, which is similar in design to sleeve *C*, is held in place by means of a washer and a set screw. The annular faces adjacent to the bores of discs *A* and the shoulder faces of sleeves *C* and *E* are inclined so that relative rotation between the discs and the sleeves is prevented.—*May* 5, 1954.

708,292. July 28, 1951.—CONSTRUCTION OF PULLEYS, Henry Ingham, 336, Blackburn Road, Haslingden, Lancaster. (*Inventors: Henry Ingham and Richard Gunton.*)

By this invention pulleys of different sizes can be built up and firmly secured on a shaft without the need for keys or other locking means. As shown in



No. 708,292

the drawing, the pulley comprises a cylindrical rim member *A* with a bore enlarged at each end forming shoulders *B* against which the peripheries of dished annular plates, forming the sides of the pulley, bear. The plates *C* are secured in the rim member by means of tie-rods or bolts *D* to draw them inwards against the shoulders *B*, this operation tending to flatten out the plates so that they are rigidly secured inside the rim. To accommodate the flattening-out action of the plates, each has radial slots *E*. The inside edges of the plates *C* are received in grooves *F* of split bosses *G* mounted on the shaft, each boss part is formed with a radial projection or lug *H*, through which the bolts are mounted. By screwing up the bolts the bosses are pulled towards one another, and the whole structure made rigid as the plates tend to flatten out inside the rim and press the bosses into tight engagement with the shaft. An alternative design is also shown in the specification.—*May* 5, 1954.

RECIPROCATING ENGINES

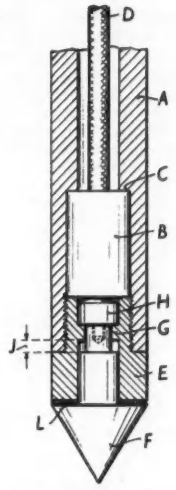
708,562. November 30, 1951.—SINTERED PISTON RINGS, Aktiengesellschaft für Bergbau und Hüttenbedarf, Salzgitter, Germany.

The invention provides a self-lubricating piston ring produced by the high-temperature sintering of powder components characterised in that the inner section of the ring is composed of a sinter metal without the addition of graphite and the outer section of the ring is composed of a sinter metal made self-lubricating by the addition of graphite. The ring is manufactured in such a way that the self-lubricating outside layer containing graphite has a thickness of 1mm to 2mm, depending on the size of the ring.—*May* 5, 1954.

CIVIL ENGINEERING

708,493. July 14, 1952.—DETERMINING THE LOAD-CARRYING CAPACITY OF SUB-STRATA, N.V. tot Aanneming van Werken voorheen H.J. Nederhorst, 8, Turfmarkt, Gouda, The Netherlands. (*Inventor: Ingenus Diederik Bakker.*)

The invention relates to apparatus for determining the load-carrying capacity of sub-strata of different depth, comprising a pressure body, a tube for driving the pressure body into the ground and a thrust responsive device which are arranged in such a way that when driving the tube into the ground the load-carrying capacity of stratum may be read directly on an indicator connected to the thrust responsive device. As the drawing shows, the lower part of the tube *A* contains the thrust responsive device *B* of known kind and having an abutment on a shoulder *C* in the tube. To the top of the thrust responsive device, which may comprise a piezo-electric crystal, an electric cable *D* is connected which transmits to an indicating device the variations of the electrical potential occurring when thrust is exerted. The device is secured in the tube by a locking body *E* screwed into the lower end of the tube and through which the upper part of the pressure body *F* extends. The locking body at its upper portion is provided with an internal abutment flange *G*. To the top of the pressure body *F* is secured a thrust head *H* which rests on the abutment flange *G* so that the pressure body is raised by the tube when this is drawn out of the ground. The head transmits the thrust of the pressure body to the responsive device. Below the abutment flange *G* a clearance *J* need not exceed the deformation of the thrust responsive device *B* for the largest load. With the arrangement overloading of the thrust responsive device is prevented.—*May* 5, 1954.

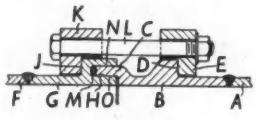


No. 708,493

TUBE AND PIPE COUPLINGS

708,263. February 19, 1951.—JOINTS BETWEEN TUBULAR PARTS, Metropolitan-Vickers Electrical Co., Ltd., St. Paul's Corner, 173, St. Paul's Churchyard, London, E.C.4. (*Inventor: Richard William Bailey.*)

The invention relates to joints between tubular parts of which one is of material having a different coefficient of thermal expansion than the material of the other part. Referring to the drawing, there is welded to the end of a ferritic steel pipe *A* a tubular part *B*. The free end of the tubular part is machined to form a circumferential spigot *C* and between the spigot and the end of the part *B* is a shoulder *D* against which there bears a loose flange *E*. To the austenitic steel pipe *F*, which is to be joined with the ferritic steel pipe *A*, there is welded an austenitic steel tubular part *G* provided at its free end with a

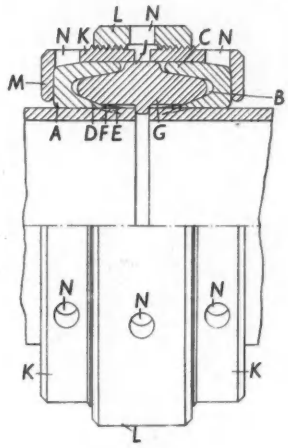


No. 708,263

circumferential groove *H* to receive the spigot *C*. Between the bottom of the groove and the end at which the part is welded to the tube is a shoulder *J* against which a loose flange *K* of austenitic steel is adapted to bear. The loose flanges *E* and *K* are held clamped to the respective shoulders of the two parts of the joint by bolts *L* of ferritic steel. Interposed between the end of the spigot *C* and the bottom of the groove *H* is packing *M* of suitably soft metal, for example, copper or a copper-aluminium alloy of superior resistance to scaling. The spigot and groove are substantially equal in width and their mean radii are such that at atmospheric temperature there will be considerable radial pressure at the inter-surface *N* between the outer surface of the spigot *C* and the groove *H* furthest from the axis of the jointed pipes. When the temperature rises the austenitic part *G* having the groove *H* will increase in free diameter more than the ferritic part *B* having the spigot *C*, so that at the normal working temperature there is no radial pressure at the interface *N* but considerable pressure at the interface *O*. Modified arrangements are also shown in the specification.—*May* 5, 1954.

708,521. January 30, 1950.—PIPE COUPLINGS, Avimo, Ltd., Vassal Charles Steer-Webster, and Stanley Redvers Rothwell, all of the company's address, Herbert Road, Rowbarton, Taunton, Somerset.

As will be seen from the drawing, a pair of collars *A* are placed round the two ends of the pipes. They have annular recesses *B*, and both walls *C* and *D* are of wedge form, the wall having an extended lip *E*. To improve the sealing action the lip is shaped as at *F* so that it bends when applied to the pipe. A third member *G* of rubber or rubber substitute engages the recesses *B*. The outer side of member *G* has an abutment rib, which engages the interior surfaces of a two-part housing *K*, made of stainless steel or other metal, which also engages the ends of the collars *A*. In making the joint the two housing parts *K* are



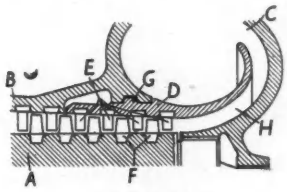
No. 708,521

positioned over the pipe ends and the two collars *A* are then stretched over the pipes with the third member *G* between. The parts *K* are then re-located over the collars and tightly screwed together by the threaded sleeve *L* or by other similar means. The axial pressure of the housing *M* on the sides of the collars forces the recesses *B* into engagement with the annular member *G*, whilst the body part of *K* confines the collars radially. The central rib is also engaged by the housing and is prevented from expanding. The combined sealing action prevents leakage. When the pipeline is charged the pressure within the pipe forces the lips *E* into sealing contact with the ends of the two pipes, and thereby prevents any kind of creep or leakage between the two collars and the surfaces of the pipes. For manipulating purposes a series of holes *N* are bored in the collars *A* and the sleeve L.—*May* 5, 1954.

AIR COMPRESSORS

708,400. June 3, 1952.—AXIAL FLOW COMPRESSORS, Sulzer Freres Societe Anonyme, Winterthur, Switzerland.

The object of the invention is to provide a multi-stage axial compressor, which can be adapted to suit different operating conditions. This is done by introducing a removable insertion which, as the drawing shows, partly bounds the outlet passage for the compressed gas, and surrounds part of the rotor which may be provided with blades. The drawing shows an insertion which may be used to compress the gas to a higher pressure, four final compression stages being provided. In the specification an insertion with two further compression



No. 708,400

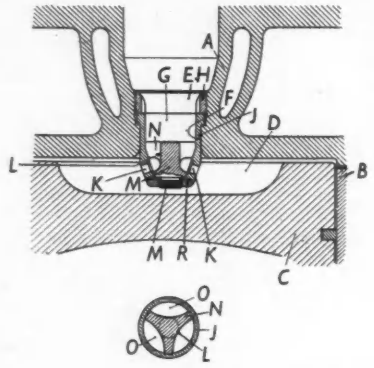
stages is also described and illustrated. As the drawing clearly shows, *A* is the compressor rotor and *B* the main rotor casing, while *C* is the delivery casing. The main casing is so constructed that it can carry alternative insertions *D* which, according to the delivery requirements, may carry the guide blades shown at *E* and the rotor blades shown at *F*. After the blading is a blade-free portion *H*, for bounding the flow passage. The insertion *D* is split

in a horizontal plane containing its axis and it is fitted into a groove *G* in the main casing. Interchangeable insertions of the kind described may also be arranged at the inlet end of the compressor so that the gas compressed may be varied in amount. By utilising interchangeable insertions at both the inlet and delivery ends of the compressor, the amount of gas compressed and its delivery pressure can be varied, and a desired relationship between these variables maintained.—*May* 5, 1954.

INTERNAL COMBUSTION ENGINES

708,371. December 28, 1951.—PRECOMBUSTION CHAMBERS, Société d'Etudes de Machines Thermiques, 24-26, rue de la Gare, La Courneuve (Seine), France.

Referring to the drawing, the cylinder head of the engine is *A*, the cylinder *B* and the piston *C*. The principal combustion chamber is *D* and *E* is a central precombustion chamber. It is formed with an aperture *F* in which a nozzle *G* is held in position by a screw-threaded ring nut *H*. The nozzle has a sleeve *J* the lower extension of which consists of a tapered portion in which peripheral orifices *K* are formed. The nozzle bottom is closed by a plug member *L*



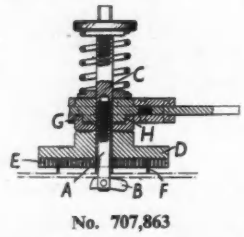
No. 708,371

consisting of a base formed with a screw-threaded portion *M* and of an upper walled portion *N* as shown. These walls form channels *O* through which the contents of the precombustion chamber may flow freely to the orifices *K*. The walls *N* are formed with tapered peripheral faces engaging the inner faces of the corresponding taper of the walls of the nozzle. A screw nut *R* forms the lower portion of the nozzle. The stress resulting from the tightening of the closing member is supported by the radial walls positioned above the level of the orifices *K*. It will be seen that in this nozzle design the portion above the orifices is reinforced by a detachable member, thereby relieving the part of the nozzle situated between the orifices from any stresses while permitting the free thermal expansion of the cylindrical nozzle body. With this particular arrangement the lower portion of the nozzle, which is subjected to high thermal loads, is relieved from any other tensions and the corrosive effect is no more to be feared. The central fuel jet is directed on to the insert or detachable member, thereby avoiding any deformation of the cylindrical nozzle. It thus becomes possible to increase the area of the orifice and the cross section of the cylindrical portion *J* with a view to reducing the losses of pressure. A modified construction is also shown in the specification.—*May* 5, 1954.

TOOLS AND WORKSHOP APPLIANCES

707,863. November 14, 1952.—TREPANNING TOOL FOR SHEET METAL, Albert George Marchant, 42, Station Road, Burgess Hill, Sussex.

Referring to the drawing of the tool, after the bolt *A* has been arranged in position with the gravity catch *B* straddling a pilot hole in the tank, a spindle *C* is screwed on to the bolt and tightened to lock the



No. 707,863

cutting head and its associated parts in position. An annular cutting head *D* is slipped over the spindle *C*. The cutting head has on the under side a series of concentric grooves or channels *E*, into any one of which may be fitted a saw *F*. The upper surface of the cutting head has three holes to receive three pins projecting from the under side of an adaptor *G*. The adaptor has its upper face formed as a "U"-shaped transverse channel *H*. A ratchet and pawl mechanism of usual design and operation is mounted on to the pillar.—*April* 21, 1954.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

FIRE HOSE AND SUCTION HOSE COUPLINGS, BRANCH PIPE AND NOZZLE CONNECTIONS

No. 336 : 1954. Price 4s. This revised standard applies to the following :—Delivery hose couplings and connectors of the instantaneous pattern, including hose couplings with ribbed and multi-serrated tails and single lug twist release connectors ; suction hose couplings, and branch pipe and nozzle connections.

In preparing this revised standard, account has been taken of present trends and practices and various modifications and additions have been made. These include the introduction of an instantaneous connector with twist release, and a material clause which provides for the use of both copper alloys and aluminium alloys.

The standard also provides for both ribbed tail pieces and multi-serrated tail pieces. The standard size of coupling adopted is that known hitherto as the "2½in gauge."

The design of the suction hose couplings has been modified and now provides for an external locking ring instead of an internally screwed sleeve. For suction couplings, a two-ribbed type of tail end has been introduced in place of the serrated type. A slight modification has also been made to the branch pipe in that a shroud has been provided to ensure that the washer is adequately retained in position.

Certain items which appeared in the 1936 edition have been excluded from this revised standard.

ADHESIVE INSULATING TAPE FOR ELECTRICAL PURPOSES

No. 1078 : 1954. Price 2s.—The new standard for adhesive insulating tape, B.S. 1078 : 1954 supersedes the war emergency specification B.S. 1078 : 1942. In general the new standard gives more details concerning methods of tests for compliance with the specification ; it differs mainly from the previous edition in that two alternative forms of ageing test are specified, and that clauses relating to slitting, properties after storage, sampling and marking are now included. Like the previous edition, however, clauses are also included which cover the description of the tape, its dimensions, breaking strength, permissible number of pinholes, and electric strength. The insulation resistance test has been excluded.

DETERMINATION OF MAGNETIC PERMEABILITY OF IRON AND STEEL BARS, FORGINGS AND CASTINGS.

No. 2454 : 1954 Price 2s. 6d. The British Standards Institution has recently published the above new British Standard, which deals with the determination of the normal magnetisation curve connecting flux density and magnetising field of iron and steel (other than permanent magnet materials) in the form of bars, forgings and castings. The preparation of this British Standard was prompted by the issue of B.S. 1617 : "Mild Steel Castings of High Magnetic Permeability." It is not, however, restricted to castings as the methods can be applied to iron and steel in any form provided the dimensions are such that the necessary test pieces can be obtained. Parts 1 to 4 of the Standard give the basic requirements of the methods and an appendix gives full details of the recommended procedure for testing ring and bar specimens.

PROTRACTORS FOR DRAWING-OFFICE USE ; FRENCH CURVES FOR DRAWING OFFICE USE ; SET SQUARES FOR DRAWING-OFFICE USE ; DRAWING INSTRUMENTS FOR DRAWING-OFFICE USE

No. 2457 : 1954 ; No. 2458 : 1954 ; No. 2459 : 1954 ; No. 2460 : 1954. Price 2s. each.

These standards are part of a series prepared by the British Standards Institution to cover the range of standard drawing-office equipment and materials. Preferred sizes are listed, based on current practice, and recommendations are made for other dimensional factors—thickness, graduations, tolerances—with the object of establishing standard ranges of articles of sound quality. In view of the considerable progress being made in the development of new plastics materials, it was decided to specify only the qualities that should be possessed by any material to be used for the manufacture of British standard protractors, French curves and set squares.

The standard sets recommended are : Full set, medium set, small set, to meet the requirements of the expert draughtsman as well as the apprentice and student. The properties of suitable metals for the manufacture of drawing instruments are set out, but no definite material is specified. Guidance is, however, provided on this subject. Manufacturing requirements are given in some detail in order to ensure uniformity of quality in instruments supplied by various makers. The dimensions and material of needles are, in particular, clearly specified. A clause on suitable cases has been added and dimensions of rectangular compartments to hold instruments of the size recommended in the standard are given. The meaning of the B.S.I. Certification Marks Scheme is explained.

BLACK TAPER WASHERS

No. 2466 : 1954. Price 2s. This standard has been prepared to overcome the confusion which has existed in the past in regard to black taper washers. Dimensions for these were previously specified in B.S. 325, "Black Cup and Countersunk Bolts, Nuts and Washers," and the standard angle was shown as 6½ deg. Nevertheless, taper washers with 5 deg. and 8 deg. angles of taper were in common use and investigations among structural engineers and manufacturers of taper washers have shown that a demand does exist for all three types. They are accordingly recognised in the new standard, but it is agreed that for the majority of structural work, where standard black bolts and nuts are used, 6½ deg. taper washers can be employed with complete efficiency and it is strongly recommended that they be regarded as standard. Dimensions and general requirements are specified for the rolled mild steel bar and malleable cast iron forms in both square and "D" shapes, to fit a range of black bolts from ⅜in to 1in inclusive. It should be noted that the provisions of this standard supersede those relating to black taper washers in B.S. 325, their deletion from which will be authorised by means of an amendment.

Launches and Trial Trips

LAOS, passenger liner ; built by the Chantiers Navals de la Ciotat for Des Messageries Maritimes ; length overall 531ft 10in, length between perpendiculars 488ft 1in, breadth 72ft 2in, depth 43ft 10in, load draught 25ft 6in, load displacement 15,150 tons, deadweight 6580 tons, gross tonnage 12,200, service speed 21 knots ; first-class and tourist-class passengers 200–227, third-class passengers (troops) 300 ; three complete decks, nine watertight bulkheads, six holds, 22 derricks, including one 20-ton and one of 50 tons capacity, electrical deck machinery, four 700kW diesel-driven generators ; two sets of C.E.M.-Parsons geared turbines, 19,500 s.h.p. at 140 r.p.m. of propeller on service, 24,000 s.h.p. on trials, steam supplied at 880 lb per square inch and 895 deg. Fah. by three "P.41" Penhoët oil-fired boilers. Trial, May.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

INSTITUTE OF NAVIGATION

Fri., June 4th.—Royal Geographical Society, 1, Kensington Gore, London, S.W.7, "Exploring the Ocean Bed," Bruno Vailati, 8.15 p.m.

Fri., June 18th.—Royal Geographical Society, 1, Kensington Gore, London, S.W.7, "Methods of Training in Navigation," Discussion introduced by W. L. S. Harrison, 5 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., June 1st.—WORKS MEETING : Great George Street, Westminster, London, S.W.1, "Civil Engineering Construction Under Water," J. R. Malcolm and J. A. Lewis, 5.30 p.m.

Tues., June 8th.—Great George Street, Westminster, London, S.W.1, Annual General Meeting, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

To-day and Sat., May 28th and 29th.—UTILIZATION SECTION : Summer Visit, Stratford-on-Avon.

Fri., June 11th.—MEASUREMENTS SECTION : Summer Visit to Rugby and Bourneville.

Fri., June 18th.—EDUCATION DISCUSSION CIRCLE : Engineering Laboratory, The Polytechnic, Battersea, Exhibition of Apparatus, 6 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

Mon., June 14th.—N.E. BRANCH : Stephenson Building, King's College, University of Durham, "The Place of Sir Charles Parsons in the History of Mechanical Engineering," Aubrey Burstall, 6 p.m.

Tues., Wed. and Fri., June 15th, 16th and 18th.—Stephenson Building, King's College, University of Durham, Sir Charles Parsons Centenary Exhibition, 7 p.m. to 8.30 p.m.

ROYAL INSTITUTION OF CHARTERED SURVEYORS

Mon., May 31st.—12, Great George Street, Westminster, London, S.W.1, Annual General Meeting, 5 p.m.

SOCIETY OF CHEMICAL INDUSTRY

Tues. to Fri., June 1st to 4th.—CORROSION GROUP : Joint Conference with the Association Belge pour l'Etude, l'Essai et l'Emploi des Materiaux (A.B.E.M.), Brussels.

WOMEN'S ENGINEERING SOCIETY

Wed., June 16th.—LONDON BRANCH : 35, Grosvenor Place, London, S.W.1, Annual General Meeting, 7 p.m.